Cisco 7100 Series VPN Configuration Guide

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Preface

This preface describes the purpose, objectives, audience, organization, and conventions of the *Cisco 7100 Series VPN Configuration Guide.*

Purpose

This software configuration guide explains the basic tasks necessary to configure IP-based, multiservice intranet and extranet Virtual Private Networks (VPNs) on your Cisco 7100 series router that integrate security and quality of service (QoS) through network technologies such as generic routing encapsulation (GRE) and IP Security Protocol (IPSec) tunneling, and high-speed encryption to ensure private transactions over public data networks. This guide does not cover every available feature; it is not intended to be a comprehensive VPN configuration guide. Instead, this guide simply explains the basic tasks necessary to configure an intranet and extranet VPN on your Cisco 7100 series router based on the GRE and IPSec tunneling protocols.

Note Although supported by Cisco 7100 series routers, this guide does not explain how to configure access VPNs using the Layer 2 Forwarding (L2F) or Layer 2 Tunnel Protocol (L2TP) tunneling protocols. Configuring access VPNs using the L2TP tunneling protocol will be covered in a later release of this guide. For detailed information on configuring client-initiated and network access server (NAS)-initiated access VPNs using the L2F tunneling protocol, refer to the *Access VPN Solutions Using Tunneling Technology* publication.

The intranet and extranet business scenarios introduced in this guide include specific tasks and configuration examples. The examples are the recommended methods for configuring the specified tasks. Although they are typically the easiest or the most straightforward method, they are not the only methods of configuring the tasks. If you know of another configuration method not presented in this guide, you can use it.

Note Use this guide after you install, power up, and initially configure your Cisco 7100 series router for network connectivity. For instructions on how to install, power up, and initially configure your Cisco 7100 series router, refer to the *Cisco 7100 Series VPN Router Installation and Configuration Guide* that shipped with your Cisco 7100 series router.

Audience

This software configuration guide is intended primarily for the following audiences:

- System administrators who are responsible for installing and configuring internetworking equipment, are familiar with the fundamentals of router-based internetworking, and who are familiar with Cisco IOS software and Cisco products
- System administrators who are familiar with the fundamentals of router-based internetworking and who are responsible for installing and configuring internetworking equipment, but who might not be familiar with the specifics of Cisco products or the routing protocols supported by Cisco products
- Customers with technical networking background and experience

Organization

The major sections of this guide are as follows:

Chapter	Title	Description
1	Using Cisco IOS Software	Provides helpful tips for understanding and configuring Cisco IOS software using the command-line interface (CLI).
2	Before You Begin	Provides an overview of the business scenarios covered in this guide, items you should consider before configuring a VPN on your Cisco 7100 series router, and the assumptions this guide makes.
3	Intranet VPN Business Scenario	Explains the basic tasks for configuring an intranet VPN on a Cisco 7100 series router using GRE as the tunneling protocol.
4	Extranet VPN Business Scenario	Explains the basic tasks for configuring an extranet VPN on a Cisco 7100 series router using IPSec as the tunneling protocol.

Where to Get the Latest Version of This Guide

The hard copy of this guide is updated at major releases only and does not always contain the latest material for enhancements occurring between major releases. You are shipped separate release notes or configuration notes for spares, hardware, and software enhancements occurring between major releases.

The online copy of this guide is always up-to-date and integrates the latest enhancements to the product. You can also access Cisco documentation on the World Wide Web at http://www.cisco.com, http://www-china.cisco.com, or http://www-europe.cisco.com.

Related Documentation

Your Cisco 7100 series router and the Cisco IOS software running on it contain extensive features and functionality, which are documented in the following resources:

- For Cisco 7100 series hardware installation and initial software configuration information, refer to the following publications:
  - *Cisco 7100 Series VPN Router Quick Start Guide*
  - *Cisco 7100 Series VPN Router Installation and Configuration Guide*
- For international agency compliance, safety, and statutory information for WAN interfaces for the Cisco 7100 series routers, refer to the *Regulatory Compliance and Safety Information for Cisco 7100 Series VPN Routers* publication that shipped with your router.
- For information on installing and replacing Cisco 7100 series field-replaceable units (FRUs), refer to the *Installing Field-Replaceable Units in Cisco 7100 Series VPN Routers* publication that shipped with your router.
- For information on using the Flash Disk, refer to the *Using the Flash Disk* publication that shipped with your router.
- For information on installing and replacing Integrated Service Module (ISM), refer to the *Integrated Service Adapter and Integrated Service Module Installation and Configuration* publication.
- For information on the port adapter installed in the router, refer to the individual installation and configuration notes that ships with each port adapter. For example, if you ordered a PA-4E Ethernet port adapter, the *PA-4E Ethernet 10BaseT Port Adapter Installation and Configuration* note is shipped with the router.
- For additional Cisco IOS software configuration information and support, refer to the modular configuration and modular command reference publications in the Cisco IOS software configuration documentation set that corresponds to the software release installed on your Cisco hardware. Specifically, you should refer to the following publications:
  - For detailed information on configuring access VPNs using the L2F tunneling protocol, refer to the *Access VPN Solutions Using Tunneling Technology* publication.

- — For information on setting up quality of service (QoS), refer to the *Quality of Service Solutions Configuration Guide* and *Quality of Service Solutions Command Reference* publications.
- — For information on encryption, refer to the *Security Configuration Guide* and the *Security Command Reference* publications.
- — For information on interfaces, refer to the *Cisco IOS Interface Configuration Guide* and the *Cisco IOS Interface Command Reference* publications.
- — For information on IP, refer to the *Network Protocols Configuration Guide, Part 1* and the *Network Protocols Command Reference, Part 1* publications.

  You can also refer to the Cisco IOS software release notes for the version of software you are using on your hardware.

- For information on network management applications, refer to the network management product documentation on Cisco Connection Online (CCO) and the Documentation CD-ROM.

  On CCO, follow this path:

  Service and Support: **Technical Documents**: **Documentation Home Page**: **Cisco Product Documentation**: **Network Management**

  On the Documentation CD-ROM, follow this path:

  Documentation CD Home Page: **Cisco Product Documentation**: **Network Management**

- To view Cisco documentation or obtain general information about the documentation, see the “Cisco Connection Online” section on page xiii and the “Documentation CD-ROM” section on page xiv, or call customer service at 800 553-6387 or 408 526-7208. Customer service hours are 5:00 a.m. to 6:00 p.m. Pacific time, Monday through Friday (excluding Cisco-observed holidays). You can also send e-mail to cs-rep@cisco.com.

Conventions

Command descriptions use the following conventions:

Convention	Description
boldface font	Commands and keywords are in **boldface**.
italic font	Arguments for which you supply values are in *italics*.
[ ]	Elements in square brackets are optional.
{*x* | *y* | *z*}	Alternative keywords are grouped in braces and separated by vertical bars.
[*x* | y | *z*]	Optional alternative keywords are grouped in brackets and separated by vertical bars.
string	A nonquoted set of characters. Do not use quotation marks around the string or the string will include the quotation marks.
`screen` font	Terminal sessions and information the system displays are in `screen` font.
`boldface screen` font	Information you must enter is in **`boldface screen`** font.
`italic screen` font	Arguments for which you supply values are in *`italic screen`* font.
——►	`This pointer highlights an important line of text in an example.`
^	The symbol ^ represents the key labeled Control—for example, the key combination ^D in a screen display means hold down the Control key while you press the D key.
< >	Nonprinting characters, such as passwords, are in angle brackets.
[ ]	Default responses to system prompts are in square brackets.
!, #	An exclamation point (!) or a pound sign (#) at the beginning of a line of code indicates a comment line.
Note	Means *reader take note*. Notes contain helpful suggestions or references to material not covered in the publication.
	**Tips** Means *the following are useful tips*.

Convention	Description
	Caution This symbol means *reader be careful*. In this situation, you might do something that could result in equipment damage or loss of data.

Cisco Connection Online

Cisco Connection Online (CCO) is Cisco Systems' primary, real-time support channel. Maintenance customers and partners can self-register on CCO to obtain additional information and services.

Available 24 hours a day, 7 days a week, CCO provides a wealth of standard and value-added services to Cisco's customers and business partners. CCO services include product information, product documentation, software updates, release notes, technical tips, the Bug Navigator, configuration notes, brochures, descriptions of service offerings, and download access to public and authorized files.

CCO serves a wide variety of users through two interfaces that are updated and enhanced simultaneously: a character-based version and a multimedia version that resides on the World Wide Web. The character-based CCO supports Zmodem, Kermit, Xmodem, FTP, and Internet e-mail, and it is excellent for quick access to information over lower bandwidths. The web version of CCO provides richly formatted documents with photographs, figures, graphics, and video, as well as hyperlinks to related information.

You can access CCO in the following ways:

- WWW: http://www.cisco.com
- WWW: http://www-europe.cisco.com
- WWW: http://www-china.cisco.com
- Telnet: cco.cisco.com
- Modem: From North America, 408 526-8070; from Europe, 33 1 64 46 40 82. Use the following terminal settings: VT100 emulation; databits: 8; parity: none; stop bits: 1; and connection rates up to 28.8 kbps.

For a copy of CCO's Frequently Asked Questions (FAQ), contact cco-help@cisco.com. For additional information, contact cco-team@cisco.com.

Note If you are a network administrator and need personal technical assistance with a Cisco product that is under warranty or covered by a maintenance contract, contact Cisco's Technical Assistance Center (TAC) at 800 553-2447, 408 526-7209, or tac@cisco.com. To obtain general information about Cisco Systems, Cisco products, or upgrades, contact 800 553-6387, 408 526-7208, or cs-rep@cisco.com.

Documentation CD-ROM

Cisco documentation and additional literature are available in a CD-ROM package, which ships with your product. The Documentation CD-ROM, a member of the Cisco Connection Family, is updated monthly. Therefore, it might be more current than printed documentation. To order additional copies of the Documentation CD-ROM, contact your local sales representative or call customer service. The CD-ROM package is available as a single package or as an annual subscription. You can also access Cisco documentation on the World Wide Web at http://www.cisco.com, http://www-china.cisco.com, or http://www-europe.cisco.com.

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CHAPTER 1

Using Cisco IOS Software

This chapter provides helpful tips for understanding and configuring Cisco IOS software using the command-line interface (CLI) and contains the following sections:

For an overview of Cisco IOS software configuration, refer to the *Configuration Fundamentals Configuration Guide*.

For information on the conventions used in this guide, see the “Conventions” section on page xii.

Getting Help

Entering a question mark (**?**) at the system prompt displays a list of commands available for each command mode. You can also get a list of any command's associated keywords and arguments with the context-sensitive help feature.

To get help specific to a command mode, a command, a keyword, or an argument, use one of the following commands:

Command	Purpose
help	Obtain a brief description of the help system in any command mode.
*abbreviated-command-entry***?**	Obtain a list of commands that begin with a particular character string. (No space between command and question mark.)
abbreviated-command-entry<**Tab**>	Complete a partial command name.
?	List all commands available for a particular command mode.
command **?**	List a command's associated keywords. (Space between command and question mark.)
command keyword **?**	List a keyword's associated arguments. (Space between the keyword and question mark.)

Note Press **Ctrl-P** or the up arrow key to recall commands in the history buffer, beginning with the most recent command. Repeat the key sequence to recall successively older commands. Press **Ctrl-N** or the down arrow key to return to more recent commands in the history buffer after recalling commands with **Ctrl-P** or the up arrow key. Repeat the key sequence to recall successively more recent commands.

The arrow keys function only on ANSI-compatible terminals such as VT100s.

Finding Command Options

This section provides an example of how to display syntax for a command. The syntax can consist of optional or required keywords. To display keywords for a command, enter a question mark (**?**) at the configuration prompt, or after entering part of a command followed by a space. The Cisco IOS software displays a list of keywords available along with a brief description of the keywords. For example, if you were in global configuration mode, typed the command **arap**, and wanted to see all the keywords for that command, you would type **arap ?**.

Table 1-1 shows how to use the question mark (**?**) to find the command options for the following two commands:

- **controller t1 1**
- **cas-group 1 timeslots 1-24 type e&m-fgb dtmf**

Table 1-1 How to Find Command Options

Command	Comment

`Router> enable`
`Password: <password>`
`Router#`
	Enter the **enable** command and password to access privileged EXEC commands.
	
	You have entered privileged EXEC mode when the prompt changes to Router#.

`Router# configure terminal`
`Enter configuration commands, one per line. End with CNTL/Z.`
`Router(config)#`
	Enter global configuration mode.
	
	You have entered global configuration mode when the prompt changes to Router(config)#.

Table 1-1 How to Find Command Options (continued)

<table>
<tr><th>Command</th><th>Comment</th></tr>
<tr><td><pre>Router(config)# controller t1 ?
  <0-3> Controller unit number
Router(config)# controller t1 1
Router(config-controller)#</pre></td><td>Enter controller configuration mode by specifying the T1 controller that you want to configure using the controller t1 global configuration command.

Enter a ? to display what you must enter next on the command line. In this example, you must enter a controller unit number from 0 to 3.

You have entered controller configuration mode when the prompt changes to Router(config-controller)#.</td></tr>
<tr><td><pre>Router(config-controller)# ?
Controller configuration commands:
  cablelength   Specify the cable length for a DS1 link
  cas-group   Configure the specified timeslots for CAS
                 (Channel Associate Signals)
  channel-group Specify the timeslots to channel-group
                 mapping for an interface
  clock   Specify the clock source for a DS1 link
  default   Set a command to its defaults
  description   Controller specific description
  ds0   ds0 commands
  exit   Exit from controller configuration mode
  fdl   Specify the FDL standard for a DS1 data link
  framing   Specify the type of Framing on a DS1 link
  help   Description of the interactive help system
  linecode   Specify the line encoding method for a DS1
                 link
  loopback   Put the entire T1 line into loopback
  no   Negate a command or set its defaults
  pri-group   Configure the specified timeslots for PRI
  shutdown   Shut down a DS1 link (send Blue Alarm)
Router(config-controller)#</pre></td><td>Enter a ? to display a list of all the controller configuration commands available for the T1 controller.</td></tr>
</table>

Table 1-1 How to Find Command Options (continued)

Command	Comment

`Router(config-controller)# cas-group ?`
`  <0-23>         Channel number`
`Router(config-controller)# cas-group`
	Enter the command that you want to configure for the controller. In this example, the **cas-group** command is used.
	
	Enter a **?** to display what you must enter next on the command line. In this example, you must enter a channel number from 0 to 23.
	
	When the system redisplays the command, it indicates that you must enter more keywords to complete the command.

`Router(config-controller)# cas-group 1 ?`
`  timeslots      List of timeslots in the cas-group`
`Router(config-controller)# cas-group 1`
	After you enter the channel number, enter a **?** to display what you must enter next on the command line. In this example, you must enter the **timeslots** keyword.
	
	When the system redisplays the command, it indicates that you must enter more keywords to complete the command.

Table 1-1 How to Find Command Options (continued)

<table>
<tr><th>Command</th><th>Comment</th></tr>
<tr><td><pre>Router(config-controller)# cas-group 1 timeslots ?
  <1-24>   List of timeslots which comprise the
                 cas-group
Router(config-controller)# cas-group 1 timeslots</pre></td><td> After you enter the timeslots keyword, enter a ? to display what you must enter next on the command line. In this example, you must enter a list of timeslots from 1 to 24. You can specify timeslot ranges (for example, 1-24), individual timeslots separated by commas (for example 1, 3, 5), or a combination of the two (for example 1-3, 8, 17-24). The 16th time slot is not specified in the command line, because it is reserved for transmitting the channel signaling. When the system redisplays the command, it indicates that you must enter more keywords to complete the command. </td></tr>
<tr><td><pre>Router(config-controller)# cas-group 1 timeslots 1-24 ?
  service   Specify the type of service
  type   Specify the type of signaling
Router(config-controller)# cas-group 1 timeslots 1-24</pre></td><td> After you enter the timeslot ranges, enter a ? to display what you must enter next on the command line. In this example, you must enter the service or type keyword. When the system redisplays the command, it indicates that you must enter more keywords to complete the command. </td></tr>
</table>

Table 1-1 How to Find Command Options (continued)

Command	Comment

Router(config-controller)# **cas-group 1 timeslots 1-24 type ?**
  e&m-fgb   E & M Type II FGB
  e&m-fgd   E & M Type IIFGD
  e&m-immediate-start E & M Immediate Start
  fxs-ground-start   FXS Ground Start
  fxs-loop-start   FXS Loop Start
  sas-ground-start   SAS Ground Start
  sas-loop-start   SAS Loop Start
Router(config-controller)# cas-group 1 timeslots 1-24 type
	In this example, the **type** keyword is entered. After you enter the **type** keyword, enter a **?** to display what you must enter next on the command line. In this example, you must enter one of the signaling types.
	
	When the system redisplays the command, it indicates that you must enter more keywords to complete the command.

Router(config-controller)# **cas-group 1 timeslots 1-24 type e&m-fgb ?**
  dtmf   DTMF tone signaling
  mf   MF tone signaling
  service   Specify the type of service
  <cr>
Router(config-controller)# cas-group 1 timeslots 1-24 type e&m-fgb
	In this example, the **e&m-fgb** keyword is entered. After you enter the **e&m-fgb** keyword, enter a **?** to display what you must enter next on the command line. In this example, you can enter the **dtmf**, **mf**, or **service** keyword to indicate the type of channel-associated signaling available for the **e&m-fgb** signaling type.
	
	When the system redisplays the command, it indicates that you can enter more keywords or press <cr> to complete the command.

Table 1-1 How to Find Command Options (continued)

Command	Comment

Router(config-controller)# **cas-group 1 timeslots 1-24 type e&m-fgb dtmf ?**
  dnis   DNIS addr info provisioned
  service   Specify the type of service
  <cr>
Router(config-controller)# cas-group 1 timeslots 1-24 type e&m-fgb dtmf
	In this example, the **dtmf** keyword is entered. After you enter the **dtmf** keyword, enter a **?** to display what you must enter next on the command line. In this example, you can enter the **dnis** or **service** keyword to indicate the options available for **dtmf** tone signaling.
	
	When the system redisplays the command, it indicates that you can enter more keywords or press <cr> to complete the command.

Router(config-controller)# **cas-group 1 timeslots 1-24 type e&m-fgb dtmf** Router(config-controller)#	In this example, enter a <cr> to complete the command.

Understanding Command Modes

The Cisco IOS user interface is divided into many different modes. The commands available to you at any given time depend on which mode you are currently in. Entering a question mark (**?**) at the system prompt allows you to obtain a list of commands available for each command mode.

When you start a session on the router, you begin in user mode, often called EXEC mode. Only a limited subset of the commands are available in EXEC mode. To have access to all commands, you must enter privileged EXEC mode (also called enable mode). Normally, you must enter a password to enter privileged EXEC mode. From privileged mode, you can enter any EXEC command or enter global configuration mode. Most of the EXEC commands are one-time commands, such as **show** commands, which show the current status of something, and **clear** commands, which clear counters or interfaces. The EXEC commands are not saved across reboots of the router.

The configuration modes allow you to make changes to the running configuration. If you later save the configuration, these commands are stored across router reboots. To get to the various configuration modes, you must start at global configuration mode. From global configuration mode, you can enter interface configuration mode, subinterface configuration mode, and a variety of protocol-specific modes.

ROM monitor mode is a separate mode used when the router cannot boot properly. If your router or access server does not find a valid system image when it is booting, or if its configuration file is corrupted at startup, the system might enter ROM monitor mode.

Summary of Main Command Modes

Table 1-2 summarizes the main command modes of the Cisco IOS software.

Table 1-2 Summary of Main Command Modes

Command Mode	Access Method	Prompt	Exit Method
User EXEC	Log in.	`Router>`	Use the **logout** command.
Privileged EXEC	From user EXEC mode, use the **enable** EXEC command.	`Router#`	To exit back to user EXEC mode, use the **disable** command. To enter global configuration mode, use the **configure terminal** privileged EXEC command.
Global configuration	From privileged EXEC mode, use the **configure terminal** privileged EXEC command.	`Router(config)#`	To exit to privileged EXEC mode, use the **exit** or **end** command or press **Ctrl-Z**. To enter interface configuration mode, enter an **interface** configuration command.

Table 1-2 Summary of Main Command Modes (continued)

Command Mode	Access Method	Prompt	Exit Method
Interface configuration	From global configuration mode, enter by specifying an interface with an **interface** command.	`Router(config-if)#`	To exit to global configuration mode, use the **exit** command. To exit to privileged EXEC mode, use the **exit** command or press **Ctrl-Z**. To enter subinterface configuration mode, specify a subinterface with the **interface** command.
Subinterface configuration	From interface configuration mode, specify a subinterface with an **interface** command.	`Router(config-subif)#`	To exit to global configuration mode, use the **exit** command. To enter privileged EXEC mode, use the **end** command or press **Ctrl-Z**.
ROM monitor	From privileged EXEC mode, use the **reload** EXEC command. Press the Break key during the first 60 seconds while the system is booting.	`>`	To exit to user EXEC mode, type **continue**.

For more information regarding command modes, refer to the “Using the Command Line Interface” chapter of the *Configuration Fundamentals Configuration Guide*.

Using the no and default Forms of Commands

Almost every configuration command also has a **no** form. In general, use the **no** form to disable a function. Use the command without the keyword **no** to reenable a disabled function or to enable a function that is disabled by default. For example, IP routing is enabled by default. To disable IP routing, specify the **no ip routing** command and specify **ip routing** to reenable it. The Cisco IOS software command references provide the complete syntax for the configuration commands and describes what the **no** form of a command does.

Configuration commands can also have a **default** form. The **default** form of a command returns the command setting to its default. Most commands are disabled by default, so the **default** form is the same as the **no** form. However, some commands are enabled by default and have variables set to certain default values. In these cases, the **default** command enables the command and sets variables to their default values. The Cisco IOS software command references describe what the **default** form of a command does if the command is not the same as the **no** form.

Saving Configuration Changes

Enter the **copy system:running-config nvram:startup-config** command to save your configuration changes to your startup configuration so that they will not be lost if there is a system reload or power outage. For example:

```
Router# copy system:running-config nvram:startup-config
Building configuration...
```

It might take a minute or two to save the configuration. After the configuration has been saved, the following output appears:

```
[OK]
Router#
```

On most platforms, this step saves the configuration to nonvolatile random-access memory (NVRAM). On Class A Flash memory file systems, such as Cisco 7100 series routers, this step saves the configuration to the location specified by the CONFIG_FILE environment variable. The CONFIG_FILE variable defaults to NVRAM.

CHAPTER 2

Before You Begin

This chapter provides an overview of the business scenarios covered in this guide, items you should consider before attempting to configure a Virtual Private Network (VPN) on your Cisco 7100 series router, and the assumptions this guide makes.

This chapter includes the following sections:

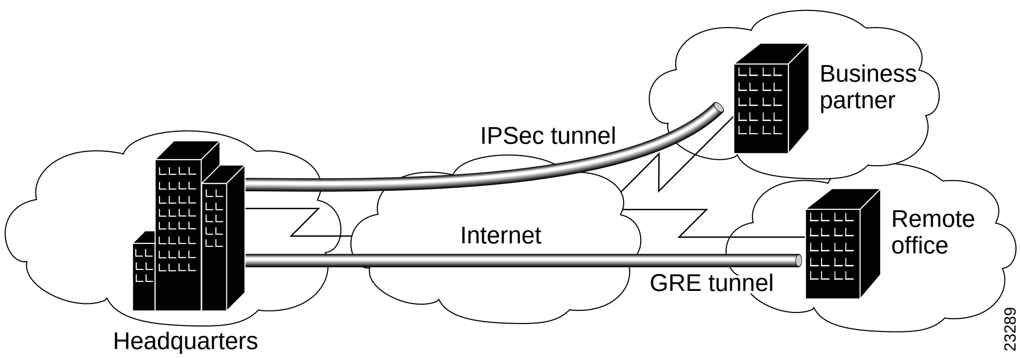
Overview of Business Scenarios

The business scenarios explained in this guide provide a remote office and a business partner access to a corporate headquarters network through secure generic routing encapsulation (GRE) and IP Security Protocol (IPSec) tunnels. (See Figure 2-1.)

Note Although supported by Cisco 7100 series routers, this guide does not explain how to configure access VPNs using the Layer 2 Forwarding (L2F) or Layer 2 Tunnel Protocol (L2TP) tunneling protocols. Configuring access VPNs using the L2TP tunneling protocol will be covered in a later release of this guide. For detailed information on configuring client-initiated and network access server (NAS)-initiated access VPNs using the L2F tunneling protocol, refer to the *Access VPN Solutions Using Tunneling Technology* publication.

In each scenario, a tunnel is constructed, encryption is applied on the tunnel, and different traffic types (for example, IP, User Datagram Protocol [UDP], and Transmission Control Protocol [TCP]) are either permitted or denied access to the tunnel. This controls the level of access the remote office and business partner have to the corporate intranet, and secures the data exchanged between the sites.

Figure 2-1 Business Scenarios



The intranet VPN business scenario explained in Chapter 3, “Intranet VPN Business Scenario,” links the corporate headquarters to a remote office using connections across the Internet. Users in the remote office are able to access resources as if they were part of the private corporate intranet.

The extranet VPN business scenario explained in Chapter 4, “Extranet VPN Business Scenario,” builds on the VPN scenario by linking the same corporate headquarters to a business partner using connections across the Internet; however, the business partner is given limited access to the headquarters network—the business partner can access only the headquarters’ public Web server.

Considerations

The following are considerations to observe when configuring a VPN on your Cisco 7100 series router:

- Syslog—Set up a syslog host, such as a CiscoWorks Essentials Workstation, and configure all the routers in the network to use the syslog host. Logging all syslog messages from the routers allows you to determine when significant events, like configuration changes, occurred.
- Telnet and Console Access—In client-initiated or network access server (NAS)-initiated access VPN environments, implement Terminal Access Controller Access Control System Plus (TACACS+) or Remote Access Dial-In User Service (RADIUS) security for Telnet and console access to the router. Doing so logs all access to the router. The addition of access lists to only allow Telnet access from particular source IP addressees helps to secure the router.
- Access Lists—Use access list numbers and names consistently to help manage and troubleshoot configurations.
- Template Configurations—Use a configuration template when deploying many routers that require consistent configurations.
- Tunneling—Observe the following when configuring tunneling:
  - To avoid anomalies that occur on physical interfaces, configure each tunnel source and destination on a loopback interface. A loopback interface is a virtual interface that is always up and allows routing protocols to stay up even if the physical interface is down.
  - Process switching and fast switching of the GRE, IPSec, L2F, and L2TP tunneling protocols, and Cisco Express Forwarding (CEF) of the IPSec tunneling protocol is supported on Cisco 7100 series routers in Cisco IOS Release 12.0(4)XE or a later 12.0 XE software release, or Cisco IOS Release 12.0(6)T or a later 12.0 T software release. CEF support of the L2F and L2TP tunneling protocols will be supported on Cisco 7100 series routers in a future maintenance release of Cisco IOS software and will be announced in the release notes that ship with the software.

  - — Be careful not to violate access control lists. You can configure a tunnel with a source and destination that are not restricted by firewall routers.
  - — Routing protocols that make their decisions based solely on hop count will often prefer a tunnel over a multipoint real link. A tunnel might appear to be a one-hop, point-to-point link and have the lowest-cost path, but may actually cost more.

- IPSec—Observe the following when configuring IPSec:
  - — IPSec works with the following serial encapsulations: High-Level Data Link Control (HDLC), Point-to-Point Protocol (PPP), and Frame Relay. IPSec also works with the GRE and IPinIP Layer 3, L2F, and L2TP tunneling protocols; however, multipoint tunnels are not supported. Other Layer 3 tunneling protocols (data-link switching [DLSW], source-route bridging [SRB], and so forth) are currently not supported for use with IPSec.
  - — IPSec and Internet Key Exchange (IKE) must be configured on the router and a crypto map assigned to all interfaces that require encryption services from the Integrated Service Module (ISM) in slot 5 of Cisco 7100 series routers.
  - — IPSec can be applied to unicast IP datagrams only. Because the IPSec Working Group has not yet addressed the issue of group key distribution, IPSec does not currently work with multicasts or broadcast IP datagrams.
  - — If you use Network Address Translation (NAT), you should configure static NAT redundant so that IPSec works properly. In general, NAT should occur before the router performs IPSec encapsulation; in other words, IPSec should be working with global addresses.
- Firewall—Observe the following when configuring Cisco IOS Firewall features (when configuring your Cisco 7100 series router as a firewall):
  - — When setting passwords for privileged access to the firewall, use the **enable secret** command rather than the **enable password** command, which does not have as strong an encryption algorithm.
  - — Configure a password on the console port. In authentication, authorization, and accounting (AAA) environments, use the same authentication for the console as for elsewhere. In a non-AAA environment, at a minimum, configure the **login** and **password** *password* commands.

— Think about access control *before* you connect a console port to the network in any way, including attaching a modem to the port. Be aware that a *break* on the console port might give total control of the firewall, even with access control configured.

— Apply access lists and password protection to all virtual terminal ports. Use access lists to limit who can Telnet into your router.

— Do not enable any local service (such as Simple Network Management Protocol [SNMP] or Network Time Protocol [NTP]) that you do not plan to use. Cisco Discovery Protocol (CDP) and NTP are on by default, and you should turn these off if you do not need them.

To turn off CDP, enter the **no cdp run** global configuration command. To turn off NTP, enter the **ntp disable** interface configuration command on each interface not using NTP.

If you must run NTP, configure NTP only on required interfaces, and configure NTP to listen only to certain peers.

Any enabled service could present a potential security risk. A determined, hostile party might be able to find creative ways to misuse the enabled services to access the firewall or the network.

For local services that are enabled, protect against misuse. Protect by configuring the services to communicate only with specific peers, and protect by configuring access lists to deny packets for the services at specific interfaces.

— Protect against spoofing: protect the networks on both sides of the firewall from being spoofed from the other side. You could protect against spoofing by configuring input access lists at all interfaces to pass only traffic from expected source addresses, and to deny all other traffic.

You should also disable source routing. For IP, enter the **no ip source-route** global configuration command. Disabling source routing at *all* routers can also help prevent spoofing.

You should also disable minor services. For IP, enter the **no service tcp-small-servers** and **no service udp-small-servers** global configuration commands.

— Prevent the firewall from being used as a relay by configuring access lists on any asynchronous Telnet ports.

- — Normally, you should disable directed broadcasts for all applicable protocols on your firewall and on all your other routers. For IP, use the **no ip directed-broadcast** command. Rarely, some IP networks do require directed broadcasts; if this is the case, do not disable directed broadcasts.

  Directed broadcasts can be misused to multiply the power of denial-of-service attacks, because every denial-of-service packet sent is broadcast to every host on a subnet. Furthermore, some hosts have other intrinsic security risks present when handling broadcasts.
- — Configure the **no proxy-arp** command to prevent internal addresses from being revealed. (This is important to do if you do not already have NAT configured to prevent internal addresses from being revealed).
- — Whenever possible, keep the firewall in a secured (locked) room.

- VPN Management—Implement one or more of the following applications on your Cisco 7100 series router for centralized, end-to-end management of both the services (for example, QoS and security features) and hardware (for example, device configuration and performance) across your VPN:
  - — CiscoWorks 2000 and CiscoView enable management of device security and configuration, and performance monitoring.
  - — CiscoWorks 2000 Access Control List Manager enables management of access control lists.
  - — Cisco QoS Policy Manager enables management of advanced bandwidth policies.
  - — Cisco Internetwork Performance Monitor 2.0 enables monitoring of service-level agreements across the service provider network.

  To access the documentation for the above applications on CCO, follow this path:

  Service and Support: **Technical Documents**: **Documentation Home Page**: **Cisco Product Documentation**: **Network Management**

  To access the documentation for the above applications on the Documentation CD-ROM, follow this path:

  Documentation CD Home Page: **Cisco Product Documentation**: **Network Management**

Assumptions

This guide assumes the following:

- You have successfully installed, powered on, and initially configured your Cisco 7100 series router for network connectivity based on the procedures explained in the *Cisco 7100 Series VPN Router Installation and Configuration Guide.*
- You are configuring a service provider transparent VPN, whereby the tunnel endpoints are outside of the service provider network (on the headquarters and remote site routers).
- You are configuring your VPN based on IP and the Border Gateway Protocol (BGP) routing protocol, and cryptography and tunneling technologies such as IPSec and GRE.
- You have Certification Authority (CA) interoperability configured on your Cisco 7100 series router. CA interoperability is provided by the ISM in support of the IPSec standard. It permits Cisco IOS devices and CAs to communicate so that your Cisco IOS device can obtain and use digital certificates from the CA. Although IPSec can be implemented in your network without the use of a CA, using a CA provides manageability and scalability for IPSec.

> **Note** The scenarios in this guide do not explain how to configure CA interoperability on your Cisco 7100 series router. For detailed configuration information on CA interoperability, refer to the "Configuring Certification Authority Interoperability" chapter in the *Security Configuration Guide*.

- You have a network management solution, such as CiscoWorks 2000, CiscoView, CiscoWorks 2000 Access Control List Manager, Cisco QoS Policy Manager, or Cisco Internetwork Performance Monitor 2.0, configured on your Cisco 7100 series router.

  For information on network management applications, refer to the network management product documentation on Cisco Connection Online (CCO) and the Documentation CD-ROM.

On CCO, follow this path:

Service and Support: **Technical Documents**: **Documentation Home Page**: **Cisco Product Documentation**: **Network Management**

On the Documentation CD-ROM, follow this path:

Documentation CD Home Page: **Cisco Product Documentation**: **Network Management**

- You have identified the Cisco IOS Firewall features that you plan to configure on your Cisco 7100 series router. The business scenarios in this guide explain how to configure extended access lists, which are sequential collections of permit and deny conditions that apply to an IP address.

Note For advanced firewall configuration information, refer to the "Traffic Filtering and Firewalls" part of the *Security Configuration Guide.*

CHAPTER 3

Intranet VPN Business Scenario

This chapter explains the basic tasks for configuring an IP-based, intranet Virtual Private Network (VPN) on a Cisco 7100 series router using generic routing encapsulation (GRE) as the tunneling protocol. Only basic security, Cisco IOS weighted fair queuing (WFQ), and extended access lists for basic traffic filtering are configured.

This chapter includes the following sections:

Note Throughout this chapter, there are numerous configuration examples and sample configuration outputs that include unusable IP addresses. Be sure to use your own IP addresses when configuring your Cisco 7100 series router.

Scenario Description

Figure 3-1 shows a headquarters network providing a remote office access to the corporate intranet. In this scenario, the headquarters and remote office are connected through a secure GRE tunnel that is established over an IP infrastructure (the Internet). Employees in the remote office are able to access internal, private web pages and perform various IP-based network tasks.

Figure 3-1 Intranet VPN Business Scenario

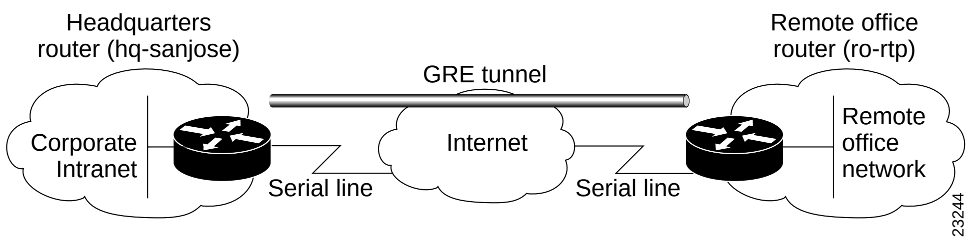
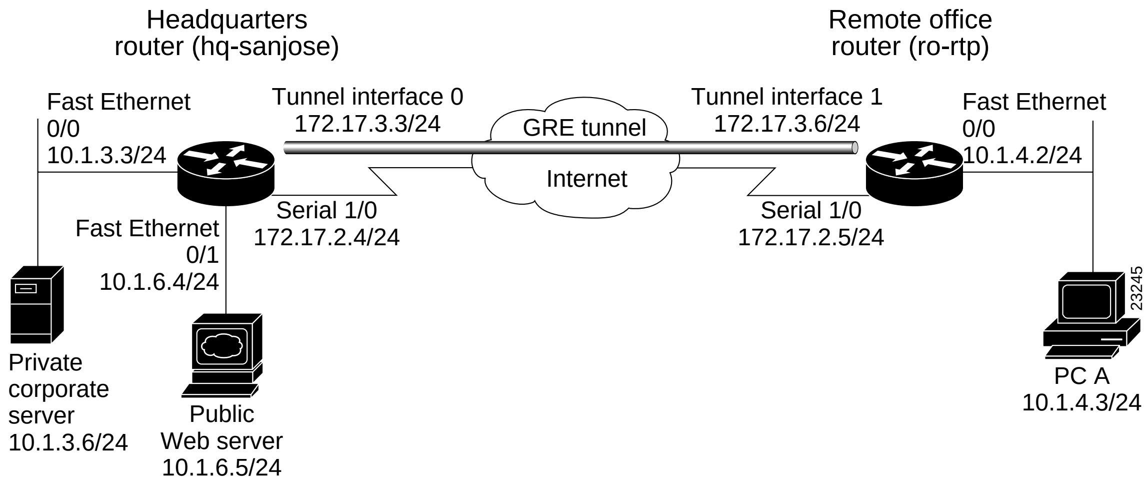


Figure 3-2 shows the physical elements of the scenario. The Internet provides the core interconnecting fabric between the headquarters and remote office routers. Both the headquarters and remote office are using a Cisco 7140-2T3 as a gateway router. Both routers have two high-speed synchronous serial T3 interfaces, two Fast Ethernet 10/100BaseT autosensing interfaces, and one Integrated Service Module (ISM) installed. The ISM provides hardware-based encryption services for any interface installed in the router.

The GRE tunnel is configured on the first serial interface in chassis slot 1 (serial 1/0) of the headquarters and remote office routers. Fast Ethernet interface 0/0 of the headquarters router is connected to a corporate server and Fast Ethernet interface 0/1 is connected to a Web server. Fast Ethernet interface 0/0 of the remote office router is connected to a PC client.

Figure 3-2 Intranet VPN Scenario Physical Elements



The configuration steps in the following sections are for the headquarters router, unless noted otherwise. Comprehensive configuration examples for both the headquarters and remote office routers are provided in the "Comprehensive Configuration Examples" section on page 3-37.

Table 3-1 lists the scenario's physical elements.

Table 3-1 Physical Elements

Headquarters Network			Remote Office Network		
Site Hardware	**WAN IP Address**	**Ethernet IP Address**	**Site Hardware**	**WAN IP Address**	**Ethernet IP Address**
hq-sanjose	Serial interface 1/0: 172.17.2.4 255.255.255.0 Tunnel interface 0: 172.17.3.3 255.255.255.0	Fast Ethernet Interface 0/0: 10.1.3.3 255.255.255.0 Fast Ethernet Interface 0/1: 10.1.6.4 255.255.255.0	ro-rtp	Serial interface 1/0: 172.17.2.5 255.255.255.0 Tunnel interface 1: 172.17.3.6 255.255.255.0	Fast Ethernet Interface 0/0: 10.1.4.2 255.255.255.0
Corporate server	–	10.1.3.6	PC A	–	10.1.4.3
Web server	–	10.1.6.5			

Step 1—Configuring the Tunnel

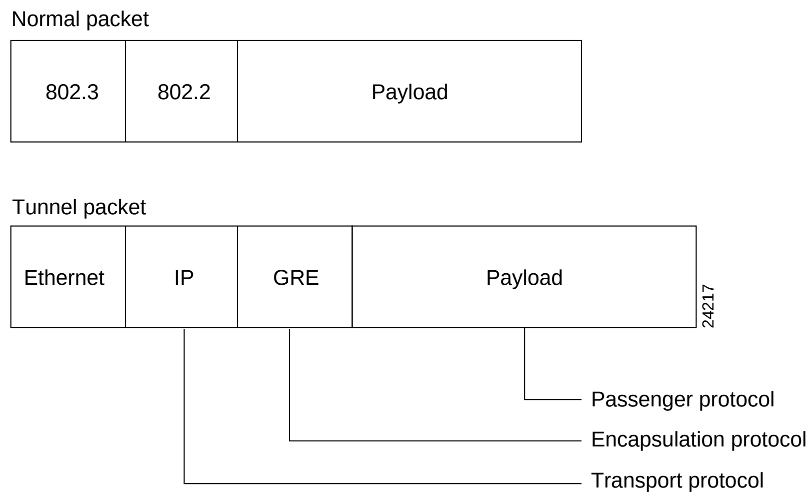
Tunneling provides a way to encapsulate packets inside of a transport protocol. Tunneling is implemented as a virtual interface to provide a simple interface for configuration. The tunnel interface is not tied to specific “passenger” or “transport” protocols, but rather, it is an architecture that is designed to provide the services necessary to implement any standard point-to-point encapsulation scheme. Because tunnels are point-to-point links, you must configure a separate tunnel for each link.

Tunneling has the following three primary components:

- Passenger protocol, which is the protocol you are encapsulating (AppleTalk, Banyan VINES, Connectionless Network Service [CLNS], DECnet, IP, or Internetwork Packet Exchange [IPX])
- Carrier protocol, such as the generic routing encapsulation (GRE) protocol
- Transport protocol, such as IP, which is the protocol used to carry the encapsulated protocol

Figure 3-3 illustrates IP tunneling terminology and concepts.

Figure 3-3 IP Tunneling Terminology and Concepts



GRE is capable of handling the transportation of multiprotocol and IP multicast traffic between two sites, which only have IP unicast connectivity. The importance of using tunnels in a VPN environment is based on the fact that IPSec encryption only works on IP unicast frames. Tunneling allows for the encryption and the transportation of multiprotocol traffic across the VPN since the tunneled packets appear to the IP network as an IP unicast frame between the tunnel endpoints. Tunnels also enable the use of private network addressing across a service provider's backbone without the need for running the Network Address Translation (NAT) feature, if all connectivity must go through the home gateway router.

This section contains basic steps to configure a GRE tunnel and includes the following tasks:

1. Configuring the Tunnel Interface, Source, and Destination
2. Verifying the Tunnel Interface, Source, and Destination

Configuring the Tunnel Interface, Source, and Destination

To configure a GRE tunnel between the headquarters and remote office routers, you must configure a tunnel interface, source, and destination on the headquarters and remote office routers. To do this, complete the following steps starting in global configuration mode.

Note The following procedure assumes the tunnel interface, source, and destination on the remote office router are configured with the values listed in Table 3-1.

Step	Command	Purpose
1	`hq-sanjose(config)#` **`interface tunnel 0`** `hq-sanjose(config-if)#` **`ip address 172.17.3.3 255.255.255.0`**	Specify a tunnel interface number, enter interface configuration mode, and configure an IP address and subnet mask on the tunnel interface. This example configures IP address and subnet mask 172.17.3.3 255.255.255.0 for tunnel interface 0 on the headquarters router.
2	`hq-sanjose(config-if)#` **`tunnel source 172.17.2.4 255.255.255.0`**	Specify the tunnel interface's source address and subnet mask. This example uses the IP address and subnet mask of T3 serial interface 1/0 of the headquarters router.
3	`hq-sanjose(config-if)#` **`tunnel destination 172.17.2.5 255.255.255.0`**	Specify the tunnel interface's destination address. This example uses the IP address and subnet mask of T3 serial interface 1/0 of the remote office router.
4	`hq-sanjose(config-if)#` **`tunnel mode gre ip`**	Configure GRE as the tunnel mode. GRE is the default tunnel encapsulation mode, so this command is considered optional.

Step	Command	Purpose
5	`hq-sanjose(config)#` **`interface tunnel 0`** `hq-sanjose(config-if)#` **`no shutdown`** `%LINK-3-UPDOWN: Interface Tunnel0, changed state to up`	Bring up the tunnel interface.[1]
6	`hq-sanjose(config-if)#` **`exit`** `hq-sanjose(config)#` **`ip route 10.1.4.0 255.255.255.0 tunnel 0`**	Exit back to global configuration mode and configure traffic from the remote office's network through the tunnel. This example configures traffic from the remote office's Fast Ethernet network (10.1.4.0 255.255.255.0) through GRE tunnel 0.

1 This command changes the state of the tunnel interface from administratively down to up.

Note When configuring GRE, you must have only Cisco routers or access servers at both ends of the tunnel connection.

Verifying the Tunnel Interface, Source, and Destination

To verify the configuration:

- Enter the **show interfaces tunnel 0** EXEC command to view the tunnel interface's status (both the interface and the interface's line protocol should be "up") and configured IP addresses and encapsulation type.

```
hq-sanjose# show interfaces tunnel 0
Tunnel0 is up, line protocol is up
  Hardware is Tunnel
  Internet address is 172.17.3.3/24
  MTU 1514 bytes, BW 180 Kbit, DLY 500000 usec,
     reliablility 255/255, txload 1/255, rxload 1/255
  Encapsulation TUNNEL, loopback not set
  Keepalive set (10 sec)
  Tunnel source 172.17.2.4, destination 172.17.2.5
  Tunnel protocol/transport GRE/IP, key disabled, sequencing disabled
  Checksumming of packets disabled,  fast tunneling enabled
  Last input never, output 00:10:44, output hang never
  Last clearing of "show interface" counters never
```

```
  Queueing strategy:fifo
  Output queue 0/0, 0 drops; input queue 0/75, 0 drops
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     0 packets input, 0 bytes, 0 no buffer
     Received 0 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     29 packets output, 2348 bytes, 0 underruns
     0 output errors, 0 collisions, 0 interface resets
     0 output buffer failures, 0 output buffers swapped out
```

- Try pinging the tunnel interface of the remote office router (this example uses the IP address of tunnel interface 1 [172.17.3.6]):

```
hq-sanjose(config)# ping 172.17.3.6

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.17.3.6, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 4/5/8 ms
```

Tips

If you have trouble, make sure you are using the correct IP address and that you enabled the tunnel interface with the **no shutdown** command.

Step 2—Configuring Quality of Service

Cisco IOS quality of service (QoS) refers to the ability of a network to provide better service to selected network traffic over various underlying technologies including Frame Relay, Asynchronous Transfer Mode (ATM), Ethernet and 802.1 networks, SONET, and IP-routed networks. In particular, QoS features provide better and more predictable network service by:

- Supporting dedicated bandwidth
- Improving loss characteristics
- Avoiding and managing network congestion
- Shaping network traffic
- Setting traffic priorities across the network

You configure QoS features throughout a network to provide for end-to-end QoS delivery. The following three components are necessary to deliver QoS across a heterogeneous network:

- QoS within a single network element, which includes queuing, scheduling, and traffic shaping features.
- QoS signaling techniques for coordinating QoS from end-to-end between network elements.
- QoS policing and management functions to control and administer end-to-end traffic across a network.

Not all QoS techniques are appropriate for all network routers. Because edge routers and backbone routers in a network do not necessarily perform the same operations, the QoS tasks they perform might differ as well.

In general, edge routers perform the following QoS functions:

- Packet classification and prioritization
- Admission control, such as queuing and policing
- Bandwidth management

In general, backbone routers perform the following QoS functions:

- Congestion management
- Congestion avoidance

Cisco IOS QoS service models, features, and sample configurations are explained in detail in the *Quality of Service Solutions Configuration Guide* and the *Quality of Service Solutions Command Reference*. Refer to these two publications as you plan and implement a QoS strategy for your VPN, because there are various QoS service models and features that you can implement on your VPN.

This section contains basic steps to configure QoS weighted fair queuing (WFQ), which applies priority (or weights) to identified traffic, on the GRE tunnel you configured in the "Step 1—Configuring the Tunnel" section on page 3-4 and includes the following tasks:

1 Configuring Weighted Fair Queuing

2 Verifying Weighted Fair Queuing

Configuring Weighted Fair Queuing

WFQ provides traffic priority management that automatically sorts among individual traffic streams without requiring that you first define access lists. WFQ can also manage duplex data streams such as those between pairs of applications, and simplex data streams such as voice or video. There are two categories of WFQ sessions: high bandwidth and low bandwidth. Low-bandwidth traffic has effective priority over high-bandwidth traffic, and high-bandwidth traffic shares the transmission service proportionally according to assigned weights.

When WFQ is enabled for an interface, new messages for high-bandwidth traffic streams are discarded after the configured or default congestive messages threshold has been met. However, low-bandwidth conversations, which include control message conversations, continue to enqueue data. As a result, the fair queue may occasionally contain more messages than its configured threshold number specifies.

With standard WFQ, packets are classified by flow. Packets with the same source IP address, destination IP address, source Transmission Control Protocol (TCP) or User Datagram Protocol (UDP) port, or destination TCP or UDP port belong to the same flow. WFQ allocates an equal share of the bandwidth to each flow. Flow-based WFQ is also called fair queuing because all flows are equally weighted.

To configure fair queuing on an interface, complete the following steps starting in global configuration mode:

Step	Command	Purpose
1	`hq-sanjose(config)#` **`interface serial 1/0`**	Specify an interface and enter interface configuration mode. This example specifies serial interface 1/0 on the headquarters router.
2	`hq-sanjose(config-if)#` **`fair-queue`**	Configure fair queuing on the interface.
3	`hq-sanjose(config-if)#` **`exit`** `hq-sanjose(config)#`	Exit back to global configuration mode.

Verifying Weighted Fair Queuing

To verify the configuration:

- Enter the **show interfaces serial 1/0 fair-queue** EXEC command to see information on the interface that is configured for WFQ.

```
hq-sanjose# show interfaces serial 1/0 fair-queue
Serial1/0 queue size 0
     packets output 35, drops 0
WFQ: global queue limit 401, local queue limit 200
```

- Enter the **show interfaces serial 1/0** EXEC command to verify the queuing for the interface is WFQ.

```
hq-sanjose# show interfaces serial 1/0
Serial1/0 is up, line protocol is up
  Hardware is M2T-T3 pa

  -Display text omitted-

  Queueing strategy:weighted fair
  Output queue:0/1000/64/0 (size/max total/threshold/drops)
     Conversations  0/0/256 (active/max active/max total)
     Reserved Conversations 0/0 (allocated/max allocated)

  -Display text omitted-
```

Step 3—Configuring Encryption

The most important part of building a VPN is maintaining security, while allowing authorized users access. The Integrated Service Module (ISM) in slot 5 of Cisco 7100 series routers provides hardware-based data encryption services for Cisco 7100 series routers. The hardware-based service provided by the ISM improves the overall performance of Cisco 7100 series routers by off-loading data encryption processing from the main system processor. The ISM supports IP Security Protocol (IPSec), Internet Key Exchange (IKE), and Certification Authority (CA) interoperability features.

IPSec is a framework of open standards, developed by the Internet Engineering Task Force (IETF), that provides data confidentiality, data integrity, and data authentication between participating peers. IPSec provides these security services at the IP layer; it uses IKE to handle negotiation of protocols and algorithms based on local policy, and to generate the encryption and authentication keys to be used by IPSec. IPSec can be used to protect one or more data flows between a pair of hosts, between a pair of security gateways, or between a security gateway and a host.

IKE is a hybrid security protocol that implements Oakley and SKEME key exchanges inside the Internet Security Association & Key Management Protocol (ISAKMP) framework. While IKE can be used with other protocols, its initial implementation is with the IPSec protocol. IKE provides authentication of the IPSec peers, negotiates IPSec security associations, and establishes IPSec keys. IPSec can be configured without IKE, but IKE enhances IPSec by providing additional features, flexibility, and ease of configuration for the IPSec standard.

CA interoperability is provided by the ISM in support of the IPSec standard. It permits Cisco IOS devices and CAs to communicate so that your Cisco IOS device can obtain and use digital certificates from the CA. Although IPSec can be implemented in your network without the use of a CA, using a CA provides manageability and scalability for IPSec.

For the ISM in slot 5 of Cisco 7100 series routers to provide encryption services on the GRE tunnel configured in the “Step 1—Configuring the Tunnel” section on page 3-4, you must complete the following steps:

1. Configuring IKE Policies (Creating policies)
2. Configuring IPSec (Creating access lists and transform sets)
3. Configuring Crypto Maps (Creating crypto maps and assigning maps to interfaces)

Optionally, you can configure CA interoperability. This guide does not explain how to configure CA interoperability on your Cisco 7100 series router. Refer to the “IP Security and Encryption” part of the *Security Configuration Guide* and the *Security Command Reference* publications for detailed information on configuring CA interoperabilty.

Note This section only contains basic configuration information for enabling encryption services on the GRE tunnel configured in the "Step 1—Configuring the Tunnel" section on page 3-4. Refer to the "IP Security and Encryption" part of the *Security Configuration Guide* and the *Security Command Reference* publications for detailed configuration information on IPSec, IKE, and CA.

Refer to the *Integrated Service Adapter and Integrated Service Module Installation and Configuration* publication for detailed configuration information on the ISM.

Configuring IKE Policies

IKE is enabled by default. IKE does not have to be enabled for individual interfaces, but is enabled globally for all interfaces in the router. You must create IKE policies at each peer. An IKE policy defines a combination of security parameters to be used during the IKE negotiation.

You can create multiple IKE policies, each with a different combination of parameter values. If you do not configure any IKE policies, the router uses the default policy, which is always set to the lowest priority, and which contains each parameter's default value.

For each policy that you create, you assign a unique priority (1 through 10,000, with 1 being the highest priority). You can configure multiple policies on each peer—but at least one of these policies must contain exactly the same encryption, hash, authentication, and Diffie-Hellman parameter values as one of the policies on the remote peer. If you do not specify a value for a parameter, the default value is assigned.

Note The default policy and the default values for configured policies do not show up in the configuration when you issue a **show running-config** EXEC command. Instead, to see the default policy and any default values within configured policies, use the **show crypto isakmp policy** EXEC command.

This section contains basic steps to configure IKE policies and includes the following tasks:

1. Creating Policies
2. Additional Configuration Required for IKE Policies
3. Verifying IKE Policies

Creating Policies

To create an IKE policy, complete the following steps starting in global configuration mode:

Step	Command	Purpose
1	`hq-sanjose(config)#` **`crypto isakmp policy 1`**	Enter config-isakmp command mode and identify the policy to create. (Each policy is uniquely identified by the priority number you assign.) This example configures policy 1.
2	`hq-sanjose(config-isakmp)#` **`encryption des`**	Specify the encryption algorithm—56-bit Data Encryption Standard (DES [**des**]) or 168-bit Triple DES (**3des**). This example configures the DES algorithm, which is the default.
3	`hq-sanjose(config-isakmp)#` **`hash sha`**	Specify the hash algorithm—Message Digest 5 (MD5 [**md5**]) or Secure Hash Algorithm (SHA [**sha**]). This example configures SHA, which is the default.
4	`hq-sanjose(config-isakmp)#` **`authentication pre-share`**	Specify the authentication method—preshared keys (**pre-share**), RSA[1] encrypted nonces (**rsa-encr**), or RSA signatures (**rsa-slg**). This example configures preshared keys. The default is RSA signatures.
5	`hq-sanjose(config-isakmp)#` **`group 1`**	Specify the Diffie-Hellman group identifier—768-bit Diffie-Hellman (**1**) or 1024-bit Diffie-Hellman (**2**). This example configures 768-bit Diffie-Hellman, which is the default.
6	`hq-sanjose(config-isakmp)#` **`lifetime 86400`**	Specify the security association's lifetime—in seconds. This example configures 86400 seconds (one day).
7	`hq-sanjose(config-isakmp)#` **`exit`** `hq-sanjose(config)#`	Exit back to global configuration mode.

1 RSA = Rivest, Shamir, and Adelman.

Additional Configuration Required for IKE Policies

Depending on which authentication method you specify in your IKE policies, you need to complete an additional companion configuration before IKE and IPSec can successfully use the IKE policies.

Each authentication method requires an additional companion configuration as follows:

- RSA signatures method:

  If you specify RSA signatures as the authentication method in a policy, you must configure the peers to obtain certificates from a Certification Authority (CA). (And, of course, the CA must be properly configured to issue the certificates.) Configure this certificate support as described in the "Configuring Certification Authority Interoperability" chapter of the *Security Configuration Guide.*

  The certificates are used by each peer to securely exchange public keys. (RSA signatures requires that each peer has the remote peer's public signature key.) When both peers have valid certificates, they will automatically exchange public keys with each other as part of any IKE negotiation in which RSA signatures are used.

- RSA encrypted nonces method:

  If you specify RSA encrypted nonces as the authentication method in a policy, you need to ensure that each peer has the other peers' public keys.

  Unlike RSA signatures, the RSA encrypted nonces method does not use certificates to exchange public keys. Instead, you ensure that each peer has the others' public keys by doing the following:

  - Manually configure RSA keys as described in the "Configuring Internet Key Exchange Security Protocol" chapter of the *Security Configuration Guide.*
  - Ensure that an IKE exchange using RSA signatures has already occurred between the peers. (The peers' public keys are exchanged during the RSA-signatures-based IKE negotiations.)

    To make this happen, specify two policies: a higher-priority policy with RSA encrypted nonces, and a lower-priority policy with RSA signatures. When IKE negotiations occur, RSA signatures will be used the first time because the peers do not yet have each others' public keys. Then, future IKE negotiations will be able to use RSA-encrypted nonces because the public keys will have been exchanged.

    Of course, this alternative requires that you have CA support configured.

- Preshared keys authentication method:

  If you specify preshared keys as the authentication method in a policy, you must configure these preshared keys as described in the following section "Configuring Preshared Keys."

If RSA encryption is configured and signature mode is negotiated, the peer will request both signature and encryption keys. Basically, the router will request as many keys as the configuration will support. If RSA encryption is not configured, it will just request a signature key.

Configuring Preshared Keys

To configure preshared keys, perform these tasks at each peer that uses preshared keys in an IKE policy:

1. Set each peer's ISAKMP identity. Each peer's identity should be set to either its host name or by its IP address. By default, a peer's identity is set to its IP address.
2. Specify the shared keys at each peer. Note that a given preshared key is shared between two peers. At a given peer, you could specify the same key to share with multiple remote peers; however, a more secure approach is to specify different keys to share between different pairs of peers.

To specify preshared keys at a peer, complete the following steps in global configuration mode:

Step	Command	Purpose
1	`hq-sanjose(config)#` **`crypto isakmp identity address`**	**At the local peer**: Specify the ISAKMP identity (**address o**r **hostname**) the headquarters router will use when communicating with the remote office router during IKE negotiations. This example specifies the **address** keyword, which uses IP address 172.17.2.4 (serial interface 1/0 of the headquarters router) as the identity for the headquarters router.

Step	Command	Purpose
2	`hq-sanjose(config)#` **`crypto isakmp key 12345 address 172.17.2.5`**	**At the local peer**: Specify the shared key the headquarters router will use with the remote office router. This example configures the shared key 12345 to be used with the remote peer 172.17.2.5 (serial interface 1/0 on the remote office router).
3	`ro-rtp(config)#` **`crypto isakmp identity address`**	**At the remote peer**: Specify the ISAKMP identity (**address o**r **hostname**) the remote office router will use when communicating with the headquarters router during IKE negotiations. Again, this example specifies the **address** keyword, which uses IP address 172.17.2.5 (serial interface 1/0 of the remote office router) as the identity for the remote office router.
4	`ro-rtp(config)#` **`crypto isakmp key 12345 address 172.17.2.4`**	**At the remote peer**: Specify the shared key to be used with the local peer. This is the same key you just specified at the local peer. This example configures the shared key 12345 to be used with the local peer 172.17.2.4 (serial interface 1/0 on the headquarters router).

Note Set an ISAKMP identity whenever you specify preshared keys. The **address** keyword is typically used when there is only one interface (and therefore only one IP address) that will be used by the peer for IKE negotiations, and the IP address is known. Use the **hostname** keyword if there is more than one interface on the peer that might be used for IKE negotiations, or if the interface's IP address is unknown (such as with dynamically-assigned IP addresses).

Verifying IKE Policies

To verify the configuration:

- Enter the **show crypto isakmp policy** EXEC command to see the default policy and any default values within configured policies.

```
hq-sanjose# show crypto isakmp policy
Protection suite priority 1
     encryption algorithm:  DES - Data Encryption Standard (56 bit keys)
     hash algorithm:        Secure Hash Standard
     authentication method: Pre-Shared Key
     Diffie-Hellman group:  #1 (768 bit)
     lifetime:              86400 seconds, no volume limit
```

Note Although the above output shows “no volume limit” for the lifetimes, you can currently only configure a time lifetime (such as 86400 seconds); volume limit lifetimes are not configurable.

Tips

If you have trouble, use the **show version** command to ensure your Cisco 7100 series router is running a Cisco IOS software image that supports crypto.

```
hq-sanjose# show version
Cisco Internetwork Operating System Software
IOS (tm) EGR Software (c7100-JOS56I-M), Release Version 12.0(4)XE
Copyright (c) 1986-1999 by cisco Systems, Inc.
Compiled Mon 22-Mar-99 21:41 by biff
Image text-base:0x600088F8, data-base:0x611CE000

ROM:System Bootstrap, Version 12.0(4)XE RELEASE SOFTWARE

router uptime is 20 hours, 34 minutes
System restarted by reload at 22:36:57 PST Fri Dec 31 1999
System image file is "c7100-jos56i-mz"

cisco 7140 (EGR) processor with 188416K/139264K bytes of memory.
R7000 CPU at 262Mhz, Implementation 39, Rev 1.0, 256KB L2, 2048KB L3
Cache
Last reset from power-on
```

```
Bridging software.
X.25 software, Version 3.0.0.
SuperLAT software copyright 1990 by Meridian Technology Corp).
TN3270 Emulation software.
3 FastEthernet/IEEE 802.3 interface(s)
2 Serial network interface(s)
125K bytes of non-volatile configuration memory.

40960K bytes of ATA PCMCIA card at slot 0 (Sector size 512 bytes).
8192K bytes of Flash internal SIMM (Sector size 256K).
Configuration register is 0x0
```

Configuring IPSec

After you have completed IKE configuration, configure IPSec at each participating IPSec peer. This section contains basic steps to configure IPSec and includes the following tasks:

1. Setting Global Lifetimes for IPSec Security Associations
2. Verifying Global Lifetimes for IPSec Security Associations
3. Creating Crypto Access Lists
4. Verifying Crypto Access Lists
5. Defining Transform Sets
6. Verifying Transform Sets

Note IKE uses UDP port 500. The IPSec encapsulating security payload (ESP) and authentication header (AH) protocols use IP protocol numbers 50 and 51. Ensure that your access lists are configured so that IP protocol 50, 51, and UDP port 500 traffic is not blocked at interfaces used by IPSec. In some cases, you might need to add a statement to your access lists to explicitly permit this traffic.

Setting Global Lifetimes for IPSec Security Associations

You can change the global lifetime values which are used when negotiating new IPSec SAs. (These global lifetime values can be overridden for a particular crypto map entry). These lifetimes only apply to security associations established using IKE. Manually established security associations do not expire.

There are two lifetimes: a “timed” lifetime and a “traffic-volume” lifetime. An SA expires after the first of these lifetimes is reached. The default lifetimes are 3600 seconds (one hour) and 4,608,000 kilobytes (10 megabytes per second for one hour).

If you change a global lifetime, the new lifetime value will not be applied to currently existing SAs, but will be used in the negotiation of subsequently established SAs. To use the new values immediately, you can clear all or part of the SA database using the **clear crypto sa** command.

IPSec SAs use one or more shared secret keys. These keys and their SAs time out together.

To change a global lifetime for IPSec SAs, enter one or more of the following commands in global configuration mode:

Command	Purpose
`hq-sanjose(config)#` **`crypto ipsec security-association lifetime seconds 3600`**	Change the global timed lifetime for IPSec SAs. This example configures the SA to time out after 3600 seconds.
`hq-sanjose(config)#` **`crypto ipsec security-association lifetime kilobytes 4608000`**	Change the global traffic-volume lifetime for IPSec SAs. This example configures the SA to time out after 4,608,000 kilobytes of traffic have passed through the IPSec tunnel using the SA.

Verifying Global Lifetimes for IPSec Security Associations

To verify the configuration:

- Enter the **show crypto ipsec security-association-lifetime** EXEC command to see global security association lifetime values.

```
hq-sanjose# show crypto ipsec security-association-lifetime
Security association lifetime:4608000 kilobytes/3600 seconds
```

Creating Crypto Access Lists

Crypto access lists are used to define which IP traffic will be protected by crypto and which traffic will not be protected by crypto. (These access lists are *not* the same as regular access lists, which determine what traffic to forward or block at an interface.) For example, you can create access lists to protect all IP traffic between the headquarters router and remote office router or Telnet traffic between the headquarters router and remote office router.

The access lists themselves are not specific to IPSec. It is the crypto map entry referencing the specific access list that defines whether IPSec processing is applied to the traffic matching a permit in the access list.

To create a crypto access list, enter the following command in global configuration mode:

Command	Purpose
`hq-sanjose(config)#` **`access-list 101 permit gre host 172.17.2.4 host 172.17.2.5`**	Specify conditions to determine which IP packets are protected.[1] (Enable or disable crypto for traffic that matches these conditions.) This example configures access list 101 to encrypt all GRE traffic between serial interface 1/0 on the headquarters router (IP address 172.17.2.4) and serial interface 1/0 on the remote office router (IP address 172.17.2.5).

1 You specify conditions using an IP access list designated by either a number or a name. The **access-list** command designates a numbered extended access list; the **ip access-list extended** command designates a named access list.

Verifying Crypto Access Lists

To verify the configuration:

- Enter the **show access-lists 101** EXEC command to see the access list's attributes.

```
hq-sanjose# show access-lists 101
Extended IP access list 101
    permit gre host 172.17.2.4 host 172.17.2.5
```

Tips

If you have trouble, make sure you are specifying the correct access list number.

Defining Transform Sets

A transform set represents a certain combination of security protocols and algorithms. During the IPSec SA negotiation, the peers agree to use a particular transform set for protecting a particular data flow.

You can specify multiple transform sets, and then specify one or more of these transform sets in a crypto map entry. The transform set defined in the crypto map entry will be used in the IPSec SA negotiation to protect the data flows specified by that crypto map entry's access list.

During IPSec SA negotiations with IKE, the peers search for a transform set that is the same at both peers. When such a transform set is found, it is selected and is applied to the protected traffic as part of both peers' IPSec SAs.

With manually established SAs, there is no negotiation with the peer, so both sides must specify the same transform set.

If you change a transform set definition, the change is only applied to crypto map entries that reference the transform set. The change will not be applied to existing SAs, but will be used in subsequent negotiations to establish new SAs.

To define a transform set, complete the following steps starting in global configuration mode:

Step	Command	Purpose
1	`hq-sanjose(config)#` **`crypto ipsec transform-set proposal1 ah-sha-hmac esp-des esp-sha-hmac`**	Define a transform set and enter crypto-transform configuration mode. This example combines AH[1] transform ah-sha-hmac, ESP[2] encryption transform esp-des, and ESP[2] authentication transform esp-sha-hmac in the transform set proposal1. There are complex rules defining which entries you can use for the transform arguments. These rules are explained in the command description for the **crypto ipsec transform-set** command. You can also use the **crypto ipsec transform-set?** command, in global configuration mode, to view the available transform arguments.

Step	Command	Purpose
2	`hq-sanjose(cfg-crypto-trans)#` **`mode transport`**	Change the mode associated with the transform set. The mode setting is only applicable to traffic whose source and destination addresses are the IPSec peer addresses; it is ignored for all other traffic. (All other traffic is in tunnel mode only.) This example configures transport mode for the transport set proposal1.
3	`hq-sanjose(cfg-crypto-trans)#` **`exit`** `hq-sanjose(config)#`	Exit back to global configuration mode.

1 AH = authentication header. This header, when added to an IP datagram, ensures the integrity and authenticity of the data, including the invariant fields in the outer IP header. It does not provide confidentiality protection. AH uses a keyed-hash function rather than digital signatures.

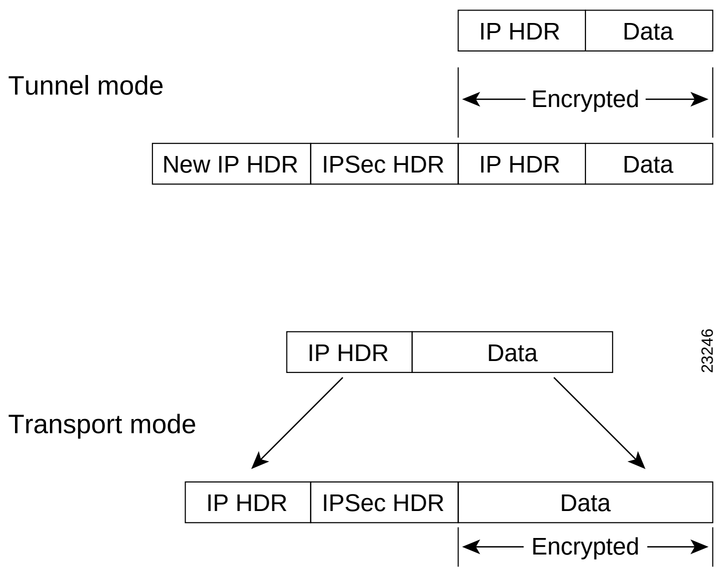
2 ESP = encapsulating security payload. This header, when added to an IP datagram, protects the confidentiality, integrity, and authenticity of the data. If ESP is used to validate data integrity, it does not include the invariant fields in the IP header.

Note AH and ESP can be used independently or together, although for most applications just one of them is sufficient. For both of these protocols, IPSec does not define the specific security algorithms to use, but rather, provides an open framework for implementing industry-standard algorithms.

Note In IPSec transport mode, only the IP payload is encrypted, and the original IP headers are left intact. (See Figure 3-4.) This mode has the advantage of adding only a few bytes to each packet. It also allows devices on the public network to see the final source and destination of the packet. This capability allows you to enable special processing (for example, QoS) in the intermediate network based on the information in the IP header. However, the Layer 4 header will be encrypted, limiting the examination of the packet. Unfortunately, by passing the IP header in the clear, transport mode allows an attacker to perform some traffic analysis.

In IPSec tunnel mode, the entire original IP datagram is encrypted, and it becomes the payload in a new IP packet. This mode allows a network device, such as a router, to act as an IPSec proxy. That is, the router performs encryption on behalf of the hosts. The source's router encrypts packets and forwards them along the IPSec tunnel. The destination's router decrypts the original IP datagram and forwards it on to the destination system. The major advantage of tunnel mode is that the end systems do not need to be modified to receive the benefits of IPSec. Tunnel mode also protects against traffic analysis; with tunnel mode an attacker can only determine the tunnel endpoints and not the true source and destination of the tunneled packets, even if they are the same as the tunnel endpoints. (See the "Defining Transform Sets and Configuring IPSec Tunnel Mode" section on page 4-13 for an IPSec tunnel configuration example.)

Figure 3-4 IPSec in Tunnel and Transport Modes



Verifying Transform Sets

To verify the configuration:

- Enter the **show crypto ipsec transform-set** EXEC command to see the type of transform set configured on the router.

```
hq-sanjose# show crypto ipsec transform-set
Transform set proposal1: { ah-sha-hmac  }
   will negotiate = { Mode,  },
   { esp-des esp-sha-hmac  }
   will negotiate = { Mode,  },
```

Configuring Crypto Maps

Crypto map entries created for IPSec pull together the various parts used to set up IPSec SAs, including:

- Which traffic should be protected by IPSec (per a crypto access list).
- The granularity of the flow to be protected by a set of SAs.
- Where IPSec-protected traffic should be sent (who the remote IPSec peer is).
- The local address to be used for the IPSec traffic. (See the "Applying Crypto Maps to Interfaces" section on page 3-30 for more details.)
- What IPSec security should be applied to this traffic (selecting from a list of one or more transform sets).
- Whether SAs are manually established or are established via IKE.
- Other parameters that might be necessary to define an IPSec SA.

Crypto map entries with the same crypto map name (but different map sequence numbers) are grouped into a crypto map set. Later, you will apply these crypto map sets to interfaces; then, all IP traffic passing through the interface is evaluated against the applied crypto map set. If a crypto map entry sees outbound IP traffic that should be protected and the crypto map specifies the use of IKE, a security association is negotiated with the remote peer according to the parameters included in the crypto map entry; otherwise, if the crypto map entry specifies the use of manual security associations, a security association should have already been established via configuration. (If a dynamic crypto map entry sees outbound traffic that should be protected and no security association exists, the packet is dropped.)

The policy described in the crypto map entries is used during the negotiation of security associations. If the local router initiates the negotiation, it will use the policy specified in the static crypto map entries to create the offer to be sent to the specified IPSec peer. If the IPSec peer initiates the negotiation, the local router will check the policy from the static crypto map entries, as well as any referenced dynamic crypto map entries to decide whether to accept or reject the peer's request (offer).

For IPSec to succeed between two IPSec peers, both peers' crypto map entries must contain compatible configuration statements.

When two peers try to establish a SA, they must each have at least one crypto map entry that is compatible with one of the other peer's crypto map entries. For two crypto map entries to be compatible, they must at least meet the following criteria:

- The crypto map entries must contain compatible crypto access lists (for example, mirror image access lists). In the case where the responding peer is using dynamic crypto maps, the entries in the local crypto access list must be "permitted" by the peer's crypto access list.
- The crypto map entries must each identify the other peer (unless the responding peer is using dynamic crypto maps).
- The crypto map entries must have at least one transform set in common.

When IKE is used to establish SAs, the IPSec peers can negotiate the settings they will use for the new SAs. This means that you can specify lists (such as lists of acceptable transforms) within the crypto map entry.

After you have completed configuring IPSec at each participating IPSec peer, configure crypto map entries and apply the crypto maps to interfaces. This section contains basic steps to configure crypto maps and includes the following tasks:

1. Creating Crypto Map Entries
2. Verifying Crypto Map Entries
3. Applying Crypto Maps to Interfaces
4. Verifying Crypto Map Interface Associations

Creating Crypto Map Entries

To create a crypto map entry that will use IKE to establish the SAs, complete the following steps starting in global configuration mode:

Step	Command	Purpose
1	`hq-sanjose(config)#` **`crypto map s1first local-address serial 1/0`**	Create the crypto map and specify a local address (physical interface) to be used for the IPSec traffic. This example creates crypto map s1first and specifies serial interface 1/0 of the headquarters router as the local address.
2	`hq-sanjose(config)#` **`crypto map s1first 1 ipsec-isakmp`**	Enter crypto map configuration mode, specify a sequence number for the crypto map you created in Step 1, and configure the crypto map to use IKE to establish SAs. This example configures sequence number 1 and IKE for crypto map s1first.
3	`hq-sanjose(config-crypto-map)#` **`match address 101`**	Specify an extended access list. This access list determines which traffic is protected by IPSec and which traffic is not be protected by IPSec. This example configures access list 101, which was created in the "Creating Crypto Access Lists" section on page 3-21.
4	`hq-sanjose(config-crypto-map)#` **`set peer 172.17.2.5`**	Specify a remote IPSec peer (by host name or IP address). This is the peer to which IPSec protected traffic can be forwarded. This example specifies serial interface 1/0 (172.17.2.5) on the remote office router.

Step	Command	Purpose
5	`hq-sanjose(config-crypto-map)#` **`set transform-set proposal1`**	Specify which transform sets are allowed for this crypto map entry. List multiple transform sets in order of priority (highest priority first). This example specifies transform set proposal1, which was configured in the "Defining Transform Sets" section on page 3-22.
6	`hq-sanjose(config-crypto-map)#` **`exit`** `hq-sanjose(config)#`	Exit back to global configuration mode.

Verifying Crypto Map Entries

To verify the configuration:

- Enter the **show crypto map** EXEC command to see the crypto map entries configured on the router.

  In the following example, peer 172.17.2.5 is the IP address of the remote IPSec peer. "Extended IP access list 101" lists the access list associated with the crypto map. "Current peer" indicates the current IPSec peer. "Security-association lifetime" indicates the lifetime of the SA. "PFS N" indicates that IPSec will not negotiate perfect forward secrecy when establishing new SAs for this crypto map. "Transform sets" indicates the name of the transform set that can be used with the crypto map.

```
hq-sanjose# show crypto map
Crypto Map: “s1first” idb: Serial1/0 local address: 172.17.2.4
Crypto Map “s1first” 1 ipsec-isakmp
        Peer = 172.17.2.5
        Extended IP access list 101
            access-list 101 permit gre
                source: addr = 172.17.2.4/255.255.255.0
                dest:   addr = 172.17.2.5/255.255.255.0
        Current peer: 172.17.2.5
        Security-association lifetime: 4608000 kilobytes/3600 seconds
        PFS (Y/N): N
        Transform sets={proposal1,}
```

Tips

If you have trouble, make sure you are using the correct IP addresses.

Applying Crypto Maps to Interfaces

You need to apply a crypto map set to each interface through which IPSec traffic will flow. Applying the crypto map set to an interface instructs the router to evaluate all the interface's traffic against the crypto map set and to use the specified policy during connection or SA negotiation on behalf of traffic to be protected by crypto.

To apply a crypto map set to an interface, complete the following steps starting in global configuration mode:

Step	Command	Purpose
1	`hq-sanjose(config)#` **`interface serial 1/0`**	Specify a physical interface on which to apply the crypto map and enter interface configuration mode. This example specifies serial interface 1/0 on the headquarters router.
2	`hq-sanjose(config-if)#` **`crypto map s1first`**	Apply the crypto map set to the physical interface. This example configures crypto map s1first, which was created in the "Creating Crypto Map Entries" section on page 3-28.
3	`hq-sanjose(config-if)#` **`exit`** `hq-sanjose(config)#`	Exit back to global configuration mode.
4	`hq-sanjose(config)#` **`interface tunnel 0`**	Specify the tunnel interface on which to apply the crypto map and enter interface configuration mode. This example specifies tunnel interface 0 on the headquarters router.
5	`hq-sanjose(config-if)#` **`crypto map s1first`**	Apply the crypto map set to the tunnel interface. This example configures crypto map s1first on the tunnel interface 0.
6	`hq-sanjose(config-if)#` **`exit`** `hq-sanjose(config)#`	Exit back to global configuration mode.

Step	Command	Purpose
7	`hq-sanjose#` **`clear crypto sa`**	In privileged EXEC mode, clear the existing IPSec SAs so that any changes are used immediately. (Manually established SAs are reestablished immediately.) **Note** Using the **clear crypto sa** command without parameters clears out the full SA database, which clears out active security sessions. You may also specify the **peer**, **map**, or **entry** keywords to clear out only a subset of the SA database.

For redundancy, you could apply the same crypto map set to more than one interface. The default behavior is as follows:

- Each interface will have its own piece of the SA database.
- The IP address of the local interface will be used as the local address for IPSec traffic originating from or destined to that interface.

If you apply the same crypto map set to multiple interfaces for redundancy purposes, you need to specify an identifying interface. This has the following effects:

- The per-interface portion of the IPSec SA database will be established one time and shared for traffic through all the interfaces that share the same crypto map.
- The IP address of the identifying interface will be used as the local address for IPSec traffic originating from or destined to those interfaces sharing the same crypto map set.

One suggestion is to use a loopback interface as the identifying interface.

Use the **crypto map** *map-name* **local-address** *interface-id* command in global configuration mode to specify redundant interfaces and name an identifying interface. This command permits redundant interfaces to share the same crypto map, using the same local identity.

Verifying Crypto Map Interface Associations

To verify the configuration:

- Enter the **show crypto map interface serial 1/0** EXEC command to see the crypto maps applied to the interface.

```
hq-sanjose# show crypto map interface serial 1/0
Crypto Map "s1first" 1 ipsec-isakmp
        Peer = 172.17.2.5
        Extended IP access list 101
            access-list 101 permit gre host 172.17.2.4 host 172.17.2.5
        Current peer:172.17.2.5
        Security association lifetime:4608000 kilobytes/1000 seconds
        PFS (Y/N):N
        Transform sets={ proposal1, }
```

- Enter the **show crypto map interface tunnel 0** EXEC command to see the crypto maps applied to the tunnel interface.

```
hq-sanjose# show crypto map interface tunnel 0
Crypto Map "s1first" 1 ipsec-isakmp
        Peer = 172.17.2.5
        Extended IP access list 101
            access-list 101 permit gre host 172.17.2.4 host 172.17.2.5
        Current peer:172.17.2.5
        Security association lifetime:4608000 kilobytes/1000 seconds
        PFS (Y/N):N
        Transform sets={ proposal1, }
```

Step 4—Configuring Cisco IOS Firewall Features

Cisco IOS software provides an extensive set of security features that allow you to configure a simple or elaborate firewall, according to your particular requirements. When you configure Cisco IOS Firewall features on your Cisco router, you turn your router into an effective, robust firewall.

Cisco IOS Firewall features are designed to prevent unauthorized, external individuals from gaining access to your internal network, and to block attacks on your network, while at the same time allowing authorized users to access network resources.

You can use Cisco IOS Firewall features to configure your Cisco IOS router as:

- An Internet firewall or part of an Internet firewall
- A firewall between groups in your internal network
- A firewall providing secure connections to or from branch offices
- A firewall between your company's network and your company's partners' networks

Cisco IOS Firewall features provides the following benefits:

- Protects internal networks from intrusion
- Monitors traffic through network perimeters
- Enables network commerce using the World Wide Web

At a minimum, you must configure basic traffic filtering to provide a basic firewall. You can configure your Cisco 7100 series router to function as a firewall by using the following Cisco IOS security features:

- Static Access Lists and Static or Dynamic Extended Access Lists
- Lock-and-Key (Dynamic Extended Access Lists)
- Reflective Access Lists
- TCP Intercept
- Context-Based Access Control
- Security Server Support
- Network Address Translation
- Cisco Encryption Technology
- IPSec Network Security
- Neighbor Router Authentication
- Event Logging
- User Authentication and Authorization

Note Refer to the "Traffic Filtering and Firewalls" part of the *Security Configuration Guide* and the *Security Command Reference* for advanced firewall configuration information.

This section explains how to configure an extended access list, which is a sequential collection of permit and deny conditions that apply to an IP address, and includes the following tasks:

1. Creating Extended Access Lists Using Access List Numbers
2. Verifying Extended Access Lists
3. Applying Access Lists to Interfaces
4. Verifying Extended Access Lists Are Applied Correctly

Note The extended access list configuration explained in this section is different from the crypto access list configuration explained in the "Creating Crypto Access Lists" section on page 3-21. Crypto access lists are used to define which IP traffic is or is not protected by crypto, while an extended access list is used to determine which IP traffic to forward or block at an interface.

The simplest connectivity to the Internet is to use a single device to provide the connectivity and firewall function to the Internet. With everything being in a single device, it is easy to address translation and termination of the VPN tunnels. Complexity arises when you need to add extra VPN gateways to the network. This normally leads people into building a network where the corporate network touches the Internet via a network called the DMZ, or demilitarized zone.

Creating Extended Access Lists Using Access List Numbers

To create an extended access list that denies and permits certain types of traffic, complete the following steps starting in global configuration mode:

Step	Command	Purpose
1	`hq-sanjose(config)#` **`access-list 102 deny tcp any any`**	Define access list 102 and configure the access list to deny all TCP traffic.
2	`hq-sanjose(config)#` **`access-list 102 deny udp any any`**	Configure access list 102 to deny all UDP traffic.
3	`hq-sanjose(config)#` **`access-list 102 permit ip any any`**	Configure access list 102 to permit all IP traffic.

Verifying Extended Access Lists

To verify the configuration:

- Enter the **show access-lists 102** EXEC command to display the contents of the access list.

```
hq-sanjose# show access-list 102
Extended IP access list 102
    deny   tcp any any
    deny   udp any any
    permit ip any any
```

Applying Access Lists to Interfaces

After you create an access list, you can apply it to one or more interfaces. Access lists can be applied on *either* outbound or inbound interfaces.

To apply an access list inbound and outbound on an interface, complete the following steps starting in global configuration mode:

Step	Command	Purpose
1	`hq-sanjose(config)#` **`interface serial 1/0`**	Specify serial interface 1/0 on the headquarters router and enter interface configuration mode.
2	`hq-sanjose(config-if)#` **`ip access-group 102 in`**	Configure access list 102 inbound on serial interface 1/0 on the headquarters router.
3	`hq-sanjose(config-if)#` **`ip access-group 102 out`**	Configure access list 102 outbound on serial interface 1/0 on the headquarters router.
4	`hq-sanjose(config-if)#` **`exit`** `hq-sanjose(config)#`	Exit back to global configuration mode.

For inbound access lists, after receiving a packet, the Cisco IOS software checks the source address of the packet against the access list. If the access list permits the address, the software continues to process the packet. If the access list rejects the address, the software discards the packet and returns an "ICMP Host Unreachable" message.

For outbound access lists, after receiving and routing a packet to a controlled interface, the software checks the destination address of the packet against the access list. If the access list permits the address, the software transmits the packet. If the access list rejects the address, the software discards the packet and returns an "ICMP Host Unreachable" message.

When you apply an access list that has not yet been defined to an interface, the software acts as if the access list has not been applied to the interface and will accept all packets. Be aware of this behavior if you use undefined access lists as a means of security in your network.

Verifying Extended Access Lists Are Applied Correctly

To verify the configuration:

- Enter the **show ip interface serial 1/0** EXEC command to confirm the access list is applied correctly (inbound and outbound) on the interface.

```
hq-sanjose# show ip interface serial 1/0
Serial1/0 is up, line protocol is up
  Internet address is 172.17.2.4
  Broadcast address is 255.255.255.255
  Address determined by setup command
  Peer address is 172.17.2.5
  MTU is 1500 bytes
  Helper address is not set
  Directed broadcast forwarding is disabled
  Outgoing access list is 102
  Inbound  access list is 102

  -Display text omitted-
```

Tips

If you have trouble, ensure that you specified the correct interface when you applied the access list.

Comprehensive Configuration Examples

Following are comprehensive sample configurations for the headquarters router and remote office router.

Headquarters Router Configuration

```
hq-sanjose# show running-config
Building configuration...

Current configuration:
!
version 12.0
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
```

```
!
hostname hq-sanjose
!
boot system flash bootflash:
boot bootldr bootflash:c7100-boot-mz.120-1.1.T
boot config slot0:hq-sanjose-cfg-small
no logging buffered
!
crypto isakmp policy 1
 authentication pre-share
 lifetime 84600
crypto isakmp key 12345 address 172.17.2.5
!
crypto ipsec transform-set proposal1 ah-sha-hmac esp-des esp-sha-hmac
mode transport
!
 !
 crypto map s1first local-address Serial1/0
 crypto map s1first 1 ipsec-isakmp
 set peer 172.17.2.5
 set transform-set proposal1
 match address 101
!
interface Tunnel0
 bandwidth 180
 ip address 172.17.3.3 255.255.255.0
 no ip directed-broadcast
 tunnel source 172.17.2.4
 tunnel destination 172.17.2.5
 crypto map s1first
!
interface FastEthernet0/0
 ip address 10.1.3.3 255.255.255.0
 no ip directed-broadcast
 no keepalive
 full-duplex
 no cdp enable
!
interface FastEthernet0/1
 ip address 10.1.6.4 255.255.255.0
 no ip directed-broadcast
 no keepalive
 full-duplex
 no cdp enable
!
```

```
interface Serial1/0
 ip address 172.17.2.4 255.255.255.0
 no ip directed-broadcast
 no ip mroute-cache
 no keepalive
 fair-queue 64 256 0
 framing c-bit
 cablelength 10
 dsu bandwidth 44210
 clock source internal
 no cdp enable
 crypto map s1first
!
ip route 10.1.4.0 255.255.255.0 Tunnel0
!
access-list 101 permit gre host 172.17.2.4 host 172.17.2.5
access-list 102 deny   tcp any any
access-list 102 deny   udp any any
access-list 102 permit ip any any
!
line con 0
 transport input none
line aux 0
line vty 0 4
 login
!
end
```

Remote Office Router Configuration

```
ro-rtp# show running-config
Building configuration...

Current configuration:
!
version 12.0
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname ro-rtp
!
boot system flash bootflash:
boot bootldr bootflash:c7100-boot-mz.120-1.1.T
boot config slot0:ro-rtp-cfg-small
no logging buffered
!
crypto isakmp policy 1
 authentication pre-share
 lifetime 84600
crypto isakmp key 12345 address 172.17.2.4
!
crypto ipsec transform-set proposal1 ah-sha-hmac esp-des esp-sha-hmac
mode transport
!
 !
 crypto map s1first local-address Serial1/0
 crypto map s1first 1 ipsec-isakmp
 set peer 172.17.2.4
 set transform-set proposal1
 match address 101
!
interface Tunnel1
 bandwidth 180
 ip address 172.17.3.6 255.255.255.0
 no ip directed-broadcast
 tunnel source 172.17.2.5
 tunnel destination 172.17.2.4
 crypto map s1first
!
```

```
interface FastEthernet0/0
 ip address 10.1.4.2 255.255.255.0
 no ip directed-broadcast
 no keepalive
 full-duplex
 no cdp enable
!
interface Serial1/0
 ip address 172.17.2.5 255.255.255.0
 no ip directed-broadcast
 no ip mroute-cache
 no keepalive
 fair-queue 64 256 0
 framing c-bit
 cablelength 10
 dsu bandwidth 44210
 clock source internal
 no cdp enable
 crypto map s1first
!
ip route 10.1.3.0 255.255.255.0 Tunnel1
ip route 10.1.6.0 255.255.255.0 Tunnel1
!
access-list 101 permit gre host 172.17.2.5 host 172.17.2.4
access-list 102 deny   tcp any any
access-list 102 deny   udp any any
access-list 102 permit ip any any
!
line con 0
 transport input none
line aux 0
line vty 0 4
 login
!
end
```

CHAPTER 4

Extranet VPN Business Scenario

This chapter explains the basic tasks for configuring an IP-based, extranet Virtual Private Network (VPN) on a Cisco 7100 series router using IP Security Protocol (IPSec) as the tunneling protocol. Only Network Address Translation (NAT), basic security, Cisco IOS weighted fair queuing (WFQ), and extended access lists for basic traffic filtering are configured.

This chapter includes the following sections:

Note Throughout this chapter, there are numerous configuration examples and sample configuration outputs that include unusable IP addresses. Be sure to use your own IP addresses when configuring your Cisco 7100 series router.

Scenario Description

The extranet scenario introduced in Figure 4-1 builds on the intranet scenario introduced in Chapter 3, “Intranet VPN Business Scenario,” by providing a business partner access to the same headquarters network. In the extranet scenario, the headquarters and business partner are connected through a secure IPSec tunnel and the business partner is given access only to the headquarters public Web server to perform various IP-based network tasks, such as placing and managing product orders.

Figure 4-1 Extranet VPN Business Scenario

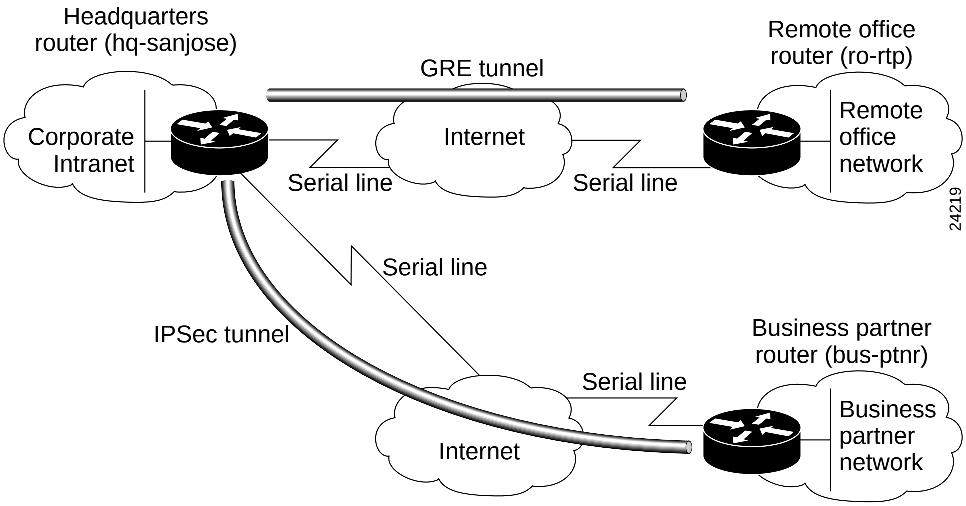
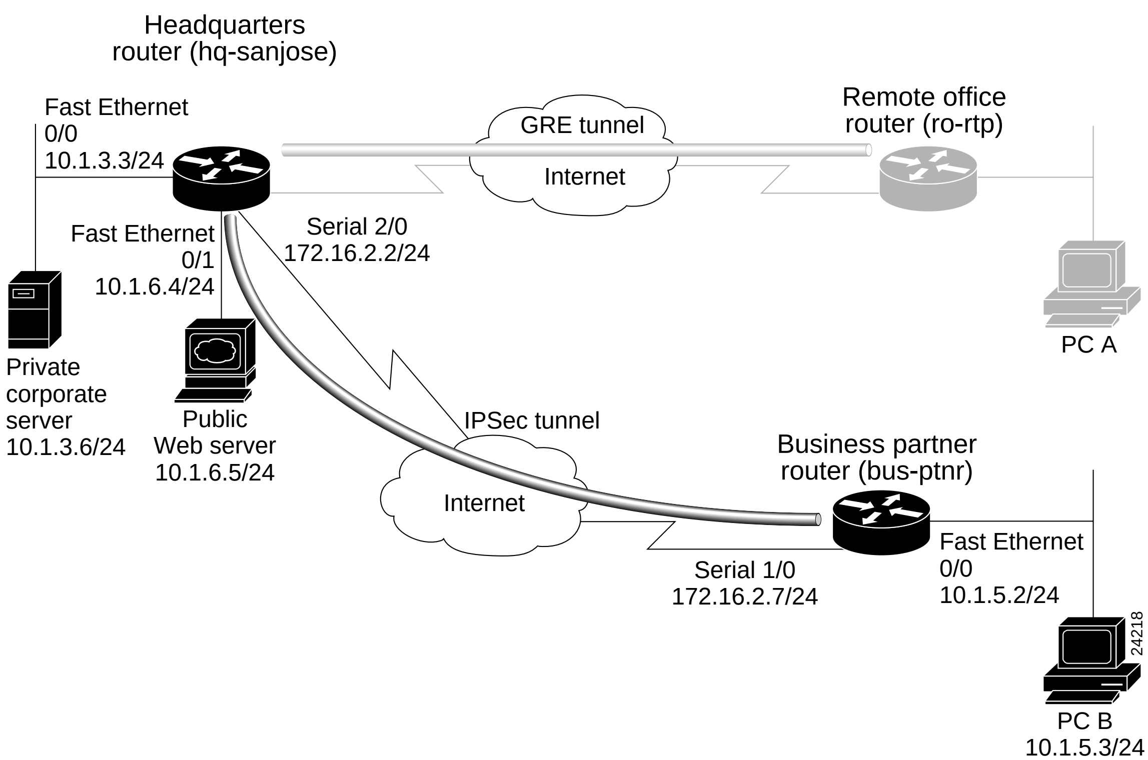


Figure 4-2 shows the physical elements of the scenario. As in the intranet business scenario explained in Chapter 3, “Intranet VPN Business Scenario,” the Internet provides the core interconnecting fabric between the headquarters and business partner routers. Like the headquarters office, the business partner is also using a Cisco 7140-2T3 as a gateway router, which has two high-speed synchronous serial T3 interfaces, two Fast Ethernet 10/100BaseT autosensing interfaces, and one Integrated Service Module (ISM) installed. The ISM provides hardware-based encryption for all interfaces installed in the router, including the IP Security Protocol (IPSec) tunneling services for the serial connection between the headquarters and business partner routers.

The IPSec tunnel between the two sites is configured on the second serial interface in chassis slot 2 (serial 2/0) of the headquarters router and the first serial interface in chassis slot 1 (serial 1/0) of the business partner router. Fast Ethernet interface 0/0 of the headquarters router is still connected to a private corporate server and Fast Ethernet interface 0/1 is connected to a public Web server. Fast Ethernet interface 0/0 of the business partner router is connected to a PC client.

Figure 4-2 Extranet VPN Scenario Physical Elements



The configuration steps in the following sections are for the headquarters router, unless noted otherwise. Comprehensive configuration examples for both the headquarters and business partner routers are provided in the "Comprehensive Configuration Examples" section on page 4-27.

Table 4-1 lists the scenario's physical elements.

Table 4-1 Physical Elements

Headquarters Network			Business Partner Network		
Site Hardware	**WAN IP Address**	**Ethernet IP Address**	**Site Hardware**	**WAN IP Address**	**Ethernet IP Address**
hq-sanjose	Serial interface 2/0: 172.16.2.2 255.255.255.0	Fast Ethernet Interface 0/0: 10.1.3.3 255.255.255.0 Fast Ethernet Interface 0/1: 10.1.6.4 255.255.255.0	bus-ptnr	Serial interface 1/0: 172.16.2.7 255.255.255.0	Fast Ethernet Interface 0/0: 10.1.5.2 255.255.255.0
Corporate server	–	10.1.3.6	PC B	–	10.1.5.3
Web server	–	10.1.6.5[1]			

1 The inside local IP address of the headquarters network's public Web server (10.1.6.5) is translated to inside global IP address 10.2.2.2 in the "Step 1—Configuring Network Address Translation" section on page 4-4.

Step 1—Configuring Network Address Translation

Network Address Translation (NAT) enables private IP internetworks that use nonregistered IP addresses to connect to the Internet. NAT is configured on the router at the border of a stub domain (referred to as the *inside network*) and a public network such as the Internet (referred to as the *outside network*). NAT translates the internal local addresses to globally unique IP addresses before sending packets to the outside network. NAT also allows a more graceful renumbering strategy for organizations that are changing service providers or voluntarily renumbering into classless interdomain routing (CIDR) blocks.

This section only explains how to configure *static translation* to translate internal local IP addresses into globally unique IP addresses before sending packets to an outside network, which includes the following tasks:

1 Configuring Static Inside Source Address Translation

2 Verifying Static Inside Source Address Translation

Static translation establishes a one-to-one mapping between your internal local address and an inside global address. Static translation is useful when a host on the inside must be accessible by a fixed address from the outside.

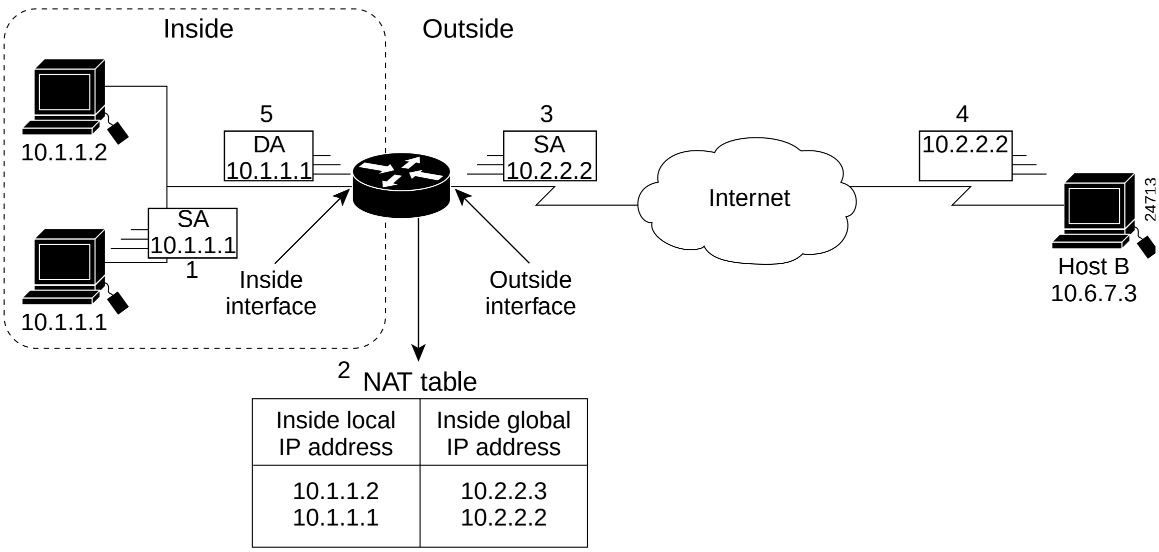
Note For detailed, additional configuration information on NAT—for example, instructions on how to configure dynamic translation—refer to the "Configuring IP Addressing" chapter in the *Network Protocols Configuration Guide, Part 1*. NAT is also described in RFC 1631.

NAT uses the following definitions:

- **Inside local address**—The IP address that is assigned to a host on the inside network. The address is probably not a legitimate IP address assigned by the Network Information Center (NIC) or service provider.
- **Inside global address**—A legitimate IP address (assigned by the NIC or service provider) that represents one or more inside local IP addresses to the outside world.
- **Outside local address**—The IP address of an outside host as it appears to the inside network. Not necessarily a legitimate address, it was allocated from address space routable on the inside.
- **Outside global address**—The IP address assigned to a host on the outside network by the host's owner. The address was allocated from globally routable address or network space.

Figure 4-3 illustrates a router that is translating a source address inside a network to a source address outside the network.

Figure 4-3 NAT Inside Source Translation



The following process describes inside source address translation, as shown in Figure 4-3:

1 The user at Host 10.1.1.1 opens a connection to Host B.

2 The first packet that the router receives from Host 10.1.1.1 causes the router to check its NAT table.

If a static translation entry was configured, the router goes to Step 3.

If no translation entry exists, the router determines that source address (SA) 10.1.1.1 must be translated dynamically, selects a legal, global address from the dynamic address pool, and creates a translation entry. This type of entry is called a *simple entry*.

3 The router replaces the inside local source address of Host 10.1.1.1 with the translation entry's global address, and forwards the packet.

4 Host B receives the packet and responds to Host 10.1.1.1 by using the inside global IP destination address (DA) 10.2.2.2.

5 When the router receives the packet with the inside global IP address, it performs a NAT table lookup by using the inside global address as a key. It then translates the address to the inside local address of Host 10.1.1.1 and forwards the packet to Host 10.1.1.1.

6 Host 10.1.1.1 receives the packet and continues the conversation. The router performs Steps 2 through 5 for each packet.

Configuring Static Inside Source Address Translation

To configure static inside source address translation, complete the following steps starting in global configuration mode:

Step	Command	Purpose
1	`hq-sanjose(config)#` **`ip nat inside source static 10.1.6.5 10.2.2.2`**	Establish static translation between an inside local address and an inside global address. This example translates inside local address 10.1.6.5 (the Web server) to inside global address 10.2.2.2.
2	`hq-sanjose(config)#` **`interface fastethernet 0/1`**	Specify the inside interface. This example specifies Fast Ethernet interface 0/1 on the headquarters router.
3	`hq-sanjose(config-if)#` **`ip nat inside`**	Mark the interface as connected to the inside.
4	`hq-sanjose(config-if)#` **`interface serial 2/0`**	Specify the outside interface. This example specifies serial interface 2/0 on the headquarters router.
5	`hq-sanjose(config-if)#` **`ip nat outside`**	Mark the interface as connected to the outside.
6	`hq-sanjose(config-if)#` **`exit`** `hq-sanjose(config)#`	Exit back to global configuration mode.

The previous steps are the minimum you must configure for static inside source address translation. You could configure multiple inside and outside interfaces.

Verifying Static Inside Source Address Translation

To verify the configuration:

- Enter the **show ip nat translations verbose** EXEC command to see the global and local address translations and to confirm static translation is configured.

```
hq-sanjose# show ip nat translations verbose
Pro Inside global      Inside local       Outside local      Outside
global
--- 10.2.2.2           10.1.6.5            ---                ---
    create 00:10:28, use 00:10:28, flags:
static
```

- Enter the **show running-config** EXEC command to see the inside and outside interfaces, global and local address translations, and to confirm static translation is configured (display text has been omitted from the following sample output for clarity).

```
hq-sanjose# show running-config

interface FastEthernet0/1
 ip address 10.1.6.5 255.255.255.0
 no ip directed-broadcast
 ip nat inside

interface serial2/0
 ip address 172.16.2.2 255.255.255.0
 ip nat outside

ip nat inside source static 10.1.6.5 10.2.2.2
```

Step 2—Configuring Encryption and an IPSec Tunnel

For the ISM in slot 5 of Cisco 7100 series routers to provide encryption and IPSec tunneling services, you must complete the following steps:

1. Configuring a Different Shared Key

Note The headquarters router and business partner router configured in this chapter use the same Internet Key Exchange (IKE) policy and priority number—policy 1— that was configured in the "Configuring IKE Policies" section on page 3-13, but with a different shared key. Only a different key for policy 1 is configured in this chapter. See the "Configuring IKE Policies" section on page 3-13 for instructions on how to configure IKE policies. If you choose to configure additional IKE policies, we recommend using a unique hash algorithm and authentication method for each additional IKE policy.

---

2. Configuring IPSec and IPSec Tunnel Mode (Creating access lists and transform sets, and configuring IPSec in tunnel mode)
3. Configuring Crypto Maps (Creating crypto maps and assigning maps to interfaces)

Optionally, you can configure Certification Authority (CA) interoperability. This guide does not explain how to configure CA interoperability on your Cisco 7100 series router. Refer to the "IP Security and Encryption" part of the *Security Configuration Guide* and the *Security Command Reference* publications for detailed information on configuring CA interoperabilty.

Note This section only contains basic configuration information for enabling encryption and IPSec tunneling services. For overview information on the ISM and configuring IKE policies, IPSec, and crypto maps, see the "Step 3—Configuring Encryption" section on page 3-11. Refer to the "IP Security and Encryption" part of the *Security Configuration Guide* and the *Security Command Reference* publications for detailed configuration information on IPSec, IKE, and CA.

Refer to the *Integrated Service Adapter and Integrated Service Module Installation and Configuration* publication for detailed configuration information on the ISM.

Configuring a Different Shared Key

Because preshared keys were specified as the authentication method for policy 1 in the "Configuring IKE Policies" section on page 3-13, (the policy that will also be used on the business partner router) complete the following tasks at the headquarters router as well as the business partner router:

1. Set each peer's Internet Security Association & Key Management Protocol (ISAKMP) identity. Each peer's identity should be set to either its host name or by its IP address. By default, a peer's identity is set to its IP address. In this scenario, you only need to complete this task at the *business partner* router.
2. Specify the shared keys at each peer. Note that a given preshared key is shared between two peers. At a given peer, you could specify the same key to share with multiple remote peers; however, a more secure approach is to specify different keys to share between different pairs of peers.

To configure a different preshared key for use between the headquarters router and the business partner router, complete the following steps in global configuration mode:

Step	Command	Purpose
1	`hq-sanjose(config)#` **`crypto isakmp key 67890 address 172.16.2.7`**	**At the local peer**: Specify the shared key the headquarters router will use with the business partner router. This example configures the shared key 67890 to be used with the remote peer 172.16.2.7 (serial interface 1/0 on the business partner router).
2	`bus-ptnr(config)#` **`crypto isakmp identity address`**	**At the remote peer**: Specify the ISAKMP identity (**address o**r **hostname**) the business partner router will use when communicating with the headquarters router during IKE negotiations. (This task was already completed on the headquarters router when policy 1 was configured in the "Configuring IKE Policies" section on page 3-13.) This example specifies the **address** keyword, which uses IP address 172.16.2.7 (serial interface 1/0 of the business partner router) as the identity for the business partner router.

Step	Command	Purpose
3	`bus-ptnr(config)#` **`crypto isakmp key 67890 address 172.17.2.4`**	**At the remote peer**: Specify the shared key to be used with the local peer. This is the same key you just specified at the local peer. This example configures the shared key 67890 to be used with the local peer 172.16.2.2 (serial interface 2/0 on the headquarters router).

Note Set an ISAKMP identity whenever you specify preshared keys. The **address** keyword is typically used when there is only one interface (and therefore only one IP address) that will be used by the peer for IKE negotiations, and the IP address is known. Use the **hostname** keyword if there is more than one interface on the peer that might be used for IKE negotiations, or if the interface's IP address is unknown (such as with dynamically-assigned IP addresses).

Configuring IPSec and IPSec Tunnel Mode

After you have configured a different shared key, configure IPSec at each participating IPSec peer. This section contains basic steps to configure IPSec and includes the following tasks:

1. Setting Global Lifetimes for IPSec Security Associations
2. Verifying Global Lifetimes for IPSec Security Associations

Note If you set global lifetimes for IPSec SAs while configuring IPSec in Chapter 3, "Intranet VPN Business Scenario," there is no need to set lifetimes again here. If you have not configured global lifetimes for IPSec SAs on your Cisco 7100 series router, see the "Setting Global Lifetimes for IPSec Security Associations" section on page 3-20 before creating your crypto access lists.

3. Creating Crypto Access Lists
4. Verifying Crypto Access Lists

5 Defining Transform Sets and Configuring IPSec Tunnel Mode

6 Verifying Transform Sets and IPSec Tunnel Mode

Note IKE uses User Datagram Protocol (UDP) port 500. The IPSec encapsulating security payload (ESP) and authentication header (AH) protocols use IP protocol numbers 50 and 51. Ensure that your access lists are configured so that IP protocol 50, 51, and UDP port 500 traffic is not blocked at interfaces used by IPSec. In some cases, you might need to add a statement to your access lists to explicitly permit this traffic.

Creating Crypto Access Lists

Crypto access lists are used to define which IP traffic will be protected by crypto and which traffic will not be protected by crypto. (These access lists are *not* the same as regular access lists, which determine what traffic to forward or block at an interface.) For example, you can create access lists to protect all IP traffic between the headquarters router and business partner router.

The access lists themselves are not specific to IPSec. It is the crypto map entry referencing the specific access list that defines whether IPSec processing is applied to the traffic matching a permit in the access list.

To create crypto a access list, enter the following command in global configuration mode:

Command	Purpose
`hq-sanjose(config)#` **`access-list 111 permit ip host 10.2.2.2 host 10.1.5.3`**	Specify conditions to determine which IP packets are protected.[1] (Enable or disable crypto for traffic that matches these conditions.) This example configures access list 111 to encrypt all IP traffic between the headquarters Web server (translated inside global IP address 10.2.2.2) and PC B (IP address 10.1.5.3) in the business partner office. We recommend that you configure “mirror image” crypto access lists for use by IPSec and that you avoid using the **any** keyword.

1 You specify conditions using an IP access list designated by either a number or a name. The **access-list** command designates a numbered extended access list; the **ip access-list extended** command designates a named access list.

Verifying Crypto Access Lists

To verify the configuration:

- Enter the **show access-lists 111** EXEC command to see access list's attributes.

```
hq-sanjose# show access-lists 111
Extended IP access list 111
    permit ip host 10.2.2.2 host 10.1.5.3
```

Tips

If you have trouble, make sure you are specifying the correct access list number.

Defining Transform Sets and Configuring IPSec Tunnel Mode

To define a transform set and configure IPSec tunnel mode, complete the following steps starting in global configuration mode:

Step	Command	Purpose
1	`hq-sanjose(config)#` **`crypto ipsec transform-set proposal4 ah-sha-hmac esp-des esp-sha-hmac`**	Define a transform set and enter crypto-transform configuration mode. This example combines AH[1] transform ah-sha-hmac, ESP[2] encryption transform esp-des, and ESP[2] authentication transform esp-sha-hmac in the transform set proposal4. There are complex rules defining which entries you can use for the transform arguments. These rules are explained in the command description for the **crypto ipsec transform-set** command. You can also use the **crypto ipsec transform-set?** command, in global configuration mode, to view the available transform arguments.

Step	Command	Purpose
2	`hq-sanjose(cfg-crypto-trans)#` **`mode tunnel`**	Change the mode associated with the transform set. The mode setting is only applicable to traffic whose source and destination addresses are the IPSec peer addresses; it is ignored for all other traffic. (All other traffic is in tunnel mode only.) This example configures tunnel mode for the transport set proposal4, which creates an IPSec tunnel between the IPSec peer addresses.
3	`hq-sanjose(cfg-crypto-trans)#` **`exit`** `hq-sanjose(config)#`	Exit back to global configuration mode.

1 AH = authentication header. This header, when added to an IP datagram, ensures the integrity and authenticity of the data, including the invariant fields in the outer IP header. It does not provide confidentiality protection. AH uses a keyed-hash function rather than digital signatures.

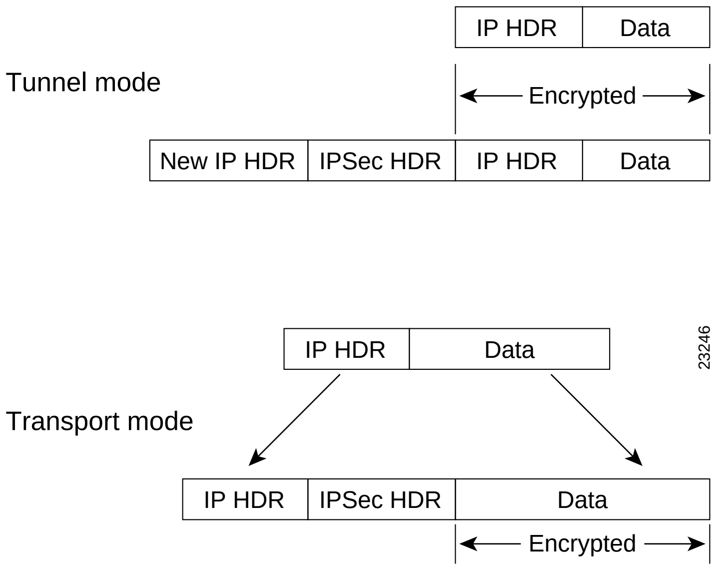
2 ESP = encapsulating security payload. This header, when added to an IP datagram, protects the confidentiality, integrity, and authenticity of the data. If ESP is used to validate data integrity, it does not include the invariant fields in the IP header.

Note AH and ESP can be used independently or together, although for most applications just one of them is sufficient. For both of these protocols, IPSec does not define the specific security algorithms to use, but rather, provides an open framework for implementing industry-standard algorithms.

Note In IPSec tunnel mode, the entire original IP datagram is encrypted, and it becomes the payload in a new IP packet. This mode allows a network device, such as a router, to act as an IPSec proxy. That is, the router performs encryption on behalf of the hosts. The source's router encrypts packets and forwards them along the IPSec tunnel. The destination's router decrypts the original IP datagram and forwards it on to the destination system. The major advantage of tunnel mode is that the end systems do not need to be modified to receive the benefits of IPSec. Tunnel mode also protects against traffic analysis; with tunnel mode an attacker can only determine the tunnel endpoints and not the true source and destination of the tunneled packets, even if they are the same as the tunnel endpoints.

In IPSec transport mode, only the IP payload is encrypted, and the original IP headers are left intact. (See Figure 4-4.) This mode has the advantage of adding only a few bytes to each packet. It also allows devices on the public network to see the final source and destination of the packet. This capability allows you to enable special processing (for example, QoS) in the intermediate network based on the information in the IP header. However, the Layer 4 header will be encrypted, limiting the examination of the packet. Unfortunately, by passing the IP header in the clear, transport mode allows an attacker to perform some traffic analysis. (See the “Defining Transform Sets” section on page 3-22 for an IPSec transport mode configuration example.)

Figure 4-4 IPSec in Tunnel and Transport Modes



Verifying Transform Sets and IPSec Tunnel Mode

To verify the configuration:

- Enter the **show crypto ipsec transform-set** EXEC command to see the type of transform set configured on the router.

```
hq-sanjose# show crypto ipsec transform-set
Transform set proposal4: { ah-sha-hmac  }
   will negotiate = { Tunnel,  },
   { esp-des esp-sha-hmac  }
   will negotiate = { Tunnel,  },

  -Display text omitted-
```

Configuring Crypto Maps

For IPSec to succeed between two IPSec peers, both peers' crypto map entries must contain compatible configuration statements.

When two peers try to establish a security association (SA), they must each have at least one crypto map entry that is compatible with one of the other peer's crypto map entries. For two crypto map entries to be compatible, they must at least meet the following criteria:

- The crypto map entries must contain compatible crypto access lists (for example, mirror image access lists). In the case where the responding peer is using dynamic crypto maps, the entries in the local crypto access list must be "permitted" by the peer's crypto access list.
- The crypto map entries must each identify the other peer (unless the responding peer is using dynamic crypto maps).
- The crypto map entries must have at least one transform set in common.

When IKE is used to establish SAs, the IPSec peers can negotiate the settings they will use for the new SAs. This means that you can specify lists (such as lists of acceptable transforms) within the crypto map entry.

After you have completed configuring IPSec at each participating IPSec peer, configure crypto map entries and apply the crypto maps to interfaces. This section contains basic steps to configure crypto maps and includes the following tasks:

1. Creating Crypto Map Entries
2. Verifying Crypto Map Entries
3. Applying Crypto Maps to Interfaces
4. Verifying Crypto Map Interface Associations

Creating Crypto Map Entries

To create crypto map entries that will use IKE to establish the SAs, complete the following steps starting in global configuration mode:

Step	Command	Purpose
1	`hq-sanjose(config)#` **`crypto map s4second local-address serial 2/0`**	Create the crypto map and specify a local address (physical interface) to be used for the IPSec traffic. This example creates crypto map s4second and specifies serial interface 2/0 of the headquarters router as the local address.
2	`hq-sanjose(config)#` **`crypto map s4second 2 ipsec-isakmp`**	Enter crypto map configuration mode, specify a sequence number for the crypto map you created in Step 1, and configure the crypto map to use IKE to establish SAs. This example configures sequence number 2 and IKE for crypto map s4second.
3	`hq-sanjose(config-crypto-map)#` **`match address 111`**	Specify an extended access list. This access list determines which traffic is protected by IPSec and which traffic is not be protected by IPSec. This example configures access list 111, which was created in the "Creating Crypto Access Lists" section on page 4-12.
4	`hq-sanjose(config-crypto-map)#` **`set peer 172.16.2.7`**	Specify a remote IPSec peer (by host name or IP address). This is the peer to which IPSec protected traffic can be forwarded. This example specifies serial interface 1/0 (172.16.2.7) on the business partner router.

Step	Command	Purpose
5	`hq-sanjose(config-crypto-map)#` **`set transform-set proposal4`**	Specify which transform sets are allowed for this crypto map entry. List multiple transform sets in order of priority (highest priority first). This example specifies transform set proposal4, which was configured in the "Defining Transform Sets and Configuring IPSec Tunnel Mode" section on page 4-13.
6	`hq-sanjose(config-crypto-map)#` **`exit`** `hq-sanjose(config)#`	Exit back to global configuration mode.

Verifying Crypto Map Entries

To verify the configuration:

- Enter the **show crypto map** EXEC command to see the crypto map entries configured on the router.

  In the following example, peer 172.16.2.7 is the IP address of the remote IPSec peer. "Extended IP access list 111" lists the access list associated with the crypto map. "Current peer" indicates the current IPSec peer. "Security-association lifetime" indicates the lifetime of the SA. "PFS N" indicates that IPSec will not negotiate perfect forward secrecy when establishing new SAs for this crypto map. "Transform sets" indicates the name of the transform set that can be used with the crypto map.

```
hq-sanjose# show crypto map
Crypto Map: "s4second" idb: Serial2/0 local address: 172.16.2.2
Crypto Map "s4second" 2 ipsec-isakmp
        Peer = 172.16.2.7
        Extended IP access list 111
            access-list 111 permit ip
                source: addr = 10.2.2.2/255.255.255.0
                dest:   addr = 10.1.5.3/255.255.255.0S
        Current peer: 172.16.2.7
        Security-association lifetime: 4608000 kilobytes/3600 seconds
        PFS (Y/N): N
        Transform sets={proposal4,}

  -Display text omitted-
```

Tips

If you have trouble, make sure you are using the correct IP addresses.

Applying Crypto Maps to Interfaces

You need to apply a crypto map set to each interface through which IPSec traffic will flow. Applying the crypto map set to an interface instructs the router to evaluate all the interface's traffic against the crypto map set and to use the specified policy during connection or SA negotiation on behalf of traffic to be protected by crypto.

To apply a crypto map set to an interface, complete the following steps starting in global configuration mode:

Step	Command	Purpose
1	`hq-sanjose(config)#` **`interface serial 2/0`**	Specify a physical interface on which to apply the crypto map and enter interface configuration mode. This example specifies serial interface 2/0 on the headquarters router.
2	`hq-sanjose(config-if)#` **`crypto map s4second`**	Apply the crypto map set to the physical interface. This example configures crypto map s4second, which was created in the "Creating Crypto Map Entries" section on page 4-18.
3	`hq-sanjose(config-if)#` **`exit`** `hq-sanjose(config)#`	Exit back to global configuration mode.
4	`hq-sanjose#` **`clear crypto sa`**	In privileged EXEC mode, clear the existing IPSec SAs so that any changes are used immediately. (Manually established SAs are reestablished immediately.) **Note** Using the **clear crypto sa** command without parameters clears out the full SA database, which clears out active security sessions. You may also specify the **peer**, **map**, or **entry** keywords to clear out only a subset of the SA database.

For redundancy, you could apply the same crypto map set to more than one interface. The default behavior is as follows:

- Each interface will have its own piece of the SA database.
- The IP address of the local interface will be used as the local address for IPSec traffic originating from or destined to that interface.

If you apply the same crypto map set to multiple interfaces for redundancy purposes, you need to specify an identifying interface. This has the following effects:

- The per-interface portion of the IPSec SA database will be established one time and shared for traffic through all the interfaces that share the same crypto map.
- The IP address of the identifying interface will be used as the local address for IPSec traffic originating from or destined to those interfaces sharing the same crypto map set.

One suggestion is to use a loopback interface as the identifying interface.

Use the **crypto map** *map-name* **local-address** *interface-id* command in global configuration mode to specify redundant interfaces and name an identifying interface. This command permits redundant interfaces to share the same crypto map, using the same local identity.

Verifying Crypto Map Interface Associations

To verify the configuration:

- Enter the **show crypto map interface serial 2/0** EXEC command to see the crypto maps applied to a specific interface.

```
hq-sanjose# show crypto map interface serial 2/0
Crypto Map "s4second" 2 ipsec-isakmp
        Peer = 172.16.2.7
        Extended IP access list 111
            access-list 111 permit ip host 10.2.2.2 host 10.1.5.3
        Current peer:172.16.2.7
        Security association lifetime:4608000 kilobytes/1000 seconds
        PFS (Y/N):N
        Transform sets={ proposal4, }
```

Step 3—Configuring Quality of Service

Cisco IOS QoS service models, features, and sample configurations are explained in detail in the *Quality of Service Solutions Configuration Guide* and the *Quality of Service Solutions Command Reference*. Refer to these two publications as you plan and implement a QoS strategy for your VPN, because there are various QoS service models and features that you can implement on your VPN.

This section just contains basic steps to configure QoS weighted fair queuing (WFQ), which applies priority (or weights) to identified traffic, on the IPSec tunnel you configured in the "Step 2—Configuring Encryption and an IPSec Tunnel" section on page 4-9 and includes the following tasks:

1. Configuring Weighted Fair Queuing
2. Verifying Weighted Fair Queuing

Note For overview information on WFQ, see the "Step 2—Configuring Quality of Service" section on page 3-8.

Configuring Weighted Fair Queuing

To configure fair queuing on an interface, complete the following steps starting in global configuration mode:

Step	Command	Purpose
1	`hq-sanjose(config)#` **`interface serial 2/0`**	Specify an interface and enter interface configuration mode. This example specifies serial interface 2/0 on the headquarters router.
2	`hq-sanjose(config-if)#` **`fair-queue`**	Configure fair queuing on the interface.
3	`hq-sanjose(config-if)#` **`exit`** `hq-sanjose(config)#`	Exit back to global configuration mode.

Verifying Weighted Fair Queuing

To verify the configuration:

- Enter the **show interfaces serial 2/0 fair-queue** EXEC command to see information on the interface that is configured for WFQ.

```
hq-sanjose# show interfaces serial 2/0 fair-queue
Serial2/0 queue size 0
     packets output 35, drops 0
WFQ: global queue limit 401, local queue limit 200
```

- Enter the **show interfaces serial 2/0** EXEC command to verify the queuing for the interface is WFQ.

```
hq-sanjose# show interfaces serial 2/0
Serial2/0 is up, line protocol is up
  Hardware is M2T-T3 pa

  -Display text omitted-

  Queueing strategy:weighted fair
  Output queue:0/1000/64/0 (size/max total/threshold/drops)
     Conversations  0/0/256 (active/max active/max total)
     Reserved Conversations 0/0 (allocated/max allocated)

  -Display text omitted-
```

Step 4—Configuring Cisco IOS Firewall Features

As discussed in Chapter 3, "Intranet VPN Business Scenario," Cisco IOS software provides an extensive set of security features that allow you to configure a simple or elaborate firewall, according to your particular requirements. An extended access list was configured in Chapter 3 to provide basic traffic filtering between the headquarters and remote office networks and to provide users in the remote office access to private and public resources on the headquarters network. The following section explains how to configure another extended access list for basic traffic filtering between the headquarters and business partner; however, the access list configured in this section provides users in the business partner office access only to the headquarters public Web server.

Note Refer to the "Traffic Filtering and Firewalls" part of the *Security Configuration Guide* and the *Security Command Reference* for advanced firewall configuration information.

This section explains how to configure an extended access list, which is a sequential collection of permit and deny conditions that apply to an IP address, and includes the following tasks:

1 Creating Extended Access Lists Using Access List Numbers

2 Verifying Extended Access Lists

3 Applying Access Lists to Interfaces

4 Verifying Extended Access Lists Are Applied Correctly

The above tasks give the PC client in the business partner office access only to the public Web server in the headquarters office. First, an extended access list is created with the appropriate deny and permit statements, then the access list is applied to the serial interface that connects the headquarters and business partner routers.

Creating Extended Access Lists Using Access List Numbers

To create an extended access list that denies and permits certain types of traffic, complete the following steps starting in global configuration mode:

Step	Command	Purpose
1	`hq-sanjose(config)#` **`access-list 112 deny tcp any any`**	Define access list 112 and configure the access list to deny all TCP traffic.
2	`hq-sanjose(config)#` **`access-list 112 deny udp any any`**	Configure access list 112 to deny all UDP traffic.
3	`hq-sanjose(config)#` **`access-list 112 permit ip host 10.2.2.2 host 10.1.5.3`**	Configure access list 112 to permit IP traffic between the headquarters Web server (translated inside global IP address 10.2.2.2) and PC B (IP address 10.1.5.3) in the business partner office.

Verifying Extended Access Lists

To verify the configuration:

- Enter the **show access-lists 112** EXEC command to display the contents of the access list.

```
hq-sanjose# show access-list 112
Extended IP access list 112
    deny   tcp any any
    deny   udp any any
    permit ip host 10.2.2.2 host 10.1.5.3
```

Applying Access Lists to Interfaces

After you create an access list, you can apply it to one or more interfaces. Access lists can be applied on *either* outbound or inbound interfaces.

To apply an access list inbound and outbound on an interface, complete the following steps starting in global configuration mode:

Step	Command	Purpose
1	`hq-sanjose(config)#` **`interface fastethernet 0/1`**	Specify Fast Ethernet interface 0/1 on the headquarters router and enter interface configuration mode.
2	`hq-sanjose(config-if)#` **`ip access-group 112 in`**	Configure access list 112 inbound on Fast Ethernet interface 0/1 on the headquarters router.
3	`hq-sanjose(config-if)#` **`interface serial 2/0`**	Specify serial interface 2/0 on the headquarters router and enter interface configuration mode.
4	`hq-sanjose(config-if)#` **`ip access-group 112 out`**	Configure access list 112 outbound on serial interface 2/0 on the headquarters router.
5	`hq-sanjose(config-if)#` **`exit`** `hq-sanjose(config)#`	Exit back to global configuration mode.

For inbound access lists, after receiving a packet, the Cisco IOS software checks the source address of the packet against the access list. If the access list permits the address, the software continues to process the packet. If the access list rejects the address, the software discards the packet and returns an "ICMP Host Unreachable" message.

For outbound access lists, after receiving and routing a packet to a controlled interface, the software checks the destination address of the packet against the access list. If the access list permits the address, the software transmits the packet. If the access list rejects the address, the software discards the packet and returns an "ICMP Host Unreachable" message.

When you apply an access list that has not yet been defined to an interface, the software acts as if the access list has not been applied to the interface and will accept all packets. Be aware of this behavior if you use undefined access lists as a means of security in your network.

Verifying Extended Access Lists Are Applied Correctly

To verify the configuration:

- Enter the **show ip interface** EXEC command to confirm the access list is applied correctly (inbound and outbound) on the interfaces.

```
hq-sanjose# show ip interface
FastEthernet0/1 is up, line protocol is up
 Internet address is 10.2.2.2

  Inbound  access list is 112

  -Display text omitted-

Serial2/0 is up, line protocol is up
  Internet address is 172.16.2.2

  Outgoing access list is 112

  -Display text omitted-
```

Tips

If you have trouble, ensure that you specified the correct interface when you applied the access list.

Comprehensive Configuration Examples

Following are comprehensive sample configurations for the headquarters router and remote business partner router.

Headquarters Router Configuration

```
hq-sanjose# show running-config
Building configuration...

Current configuration:
!
version 12.0
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname hq-sanjose
!
boot system flash bootflash:
boot bootldr bootflash:c7100-boot-mz.120-1.1.T
boot config slot0:hq-sanjose-cfg-small
no logging buffered
!
crypto isakmp policy 1
 authentication pre-share
 lifetime 84600
crypto isakmp key 12345 address 172.17.2.5
crypto isakmp key 67890 address 172.16.2.7
!
crypto ipsec transform-set proposal1 ah-sha-hmac esp-des esp-sha-hmac
mode transport
!
crypto ipsec transform-set proposal4 ah-sha-hmac esp-des esp-sha-hmac
!
 !
 crypto map s1first local-address Serial1/0
 crypto map s1first 1 ipsec-isakmp
 set peer 172.17.2.5
 set transform-set proposal1
 match address 101
 !
 crypto map s4second local-address Serial2/0
 crypto map s4second 2 ipsec-isakmp
```

```
 set peer 172.16.2.7
 set transform-set proposal4
 match address 111
!
interface Tunnel0
 bandwidth 180
 ip address 172.17.3.3 255.255.255.0
 no ip directed-broadcast
 tunnel source 172.17.2.4
 tunnel destination 172.17.2.5
 crypto map s1first
!
interface FastEthernet0/0
 ip address 10.1.3.3 255.255.255.0
 no ip directed-broadcast
 no keepalive
 full-duplex
 no cdp enable
!
interface FastEthernet0/1
 ip address 10.1.6.4 255.255.255.0
 no ip directed-broadcast
 ip nat inside
 no keepalive
 full-duplex
 no cdp enable
!
interface Serial1/0
 ip address 172.17.2.4 255.255.255.0
 no ip directed-broadcast
 no ip mroute-cache
 no keepalive
 fair-queue 64 256 0
 framing c-bit
 cablelength 10
 dsu bandwidth 44210
 clock source internal
 no cdp enable
 crypto map s1first
!
interface Serial2/0
 ip address 172.16.2.2 255.255.255.0
 no ip directed-broadcast
 ip nat outside
 no ip mroute-cache
```

```
 no keepalive
 fair-queue 64 256 0
 framing c-bit
 cablelength 10
 dsu bandwidth 44210
 clock source internal
 no cdp enable
 crypto map s4second
!
router bgp 10
 network 10.2.2.2 mask 255.255.255.0
 network 172.16.2.0 mask 255.255.255.0
!
ip route 10.1.4.0 255.255.255.0 Tunnel0
!
ip nat inside source static 10.1.6.5 10.2.2.2
!
access-list 101 permit gre host 172.17.2.4 host 172.17.2.5
access-list 102 deny   tcp any any
access-list 102 deny   udp any any
access-list 102 permit ip any any
access-list 111 permit ip host 10.2.2.2 host 10.1.5.3
access-list 112 deny   tcp any any
access-list 112 deny   udp any any
access-list 112 permit ip host 10.2.2.2 host 10.1.5.3
!
line con 0
 transport input none
line aux 0
line vty 0 4
 login
!
end
```

Business Partner Router Configuration

```
bus-ptnr# show running-config
Building configuration...

Current configuration:
!
version 12.0
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname bus-ptnr
!
boot system flash bootflash:
boot bootldr bootflash:c7100-boot-mz.120-1.1.T
boot config slot0:bus-ptnr-cfg-small
no logging buffered
!
crypto isakmp policy 1
 authentication pre-share
 lifetime 84600
crypto isakmp key 67890 address 172.16.2.2
!
crypto ipsec transform-set proposal4 ah-sha-hmac esp-des esp-sha-hmac
!
 !
 crypto map s4second local-address Serial1/0
 crypto map s4second 2 ipsec-isakmp
 set peer 172.16.2.2
 set transform-set proposal4
 match address 111
!
interface FastEthernet0/0
 ip address 10.1.5.2 255.255.255.0
 no ip directed-broadcast
 no keepalive
 full-duplex
 no cdp enable
!
interface Serial1/0
 ip address 172.16.2.7 255.255.255.0
 no ip directed-broadcast
 no ip mroute-cache
 no keepalive
```

```
 fair-queue 64 256 0
 framing c-bit
 cablelength 10
 dsu bandwidth 44210
 clock source internal
 no cdp enable
 crypto map s4second
!
router bgp 10
 network 10.1.5.0 mask 255.255.255.0
 network 172.16.2.0 mask 255.255.255.0
!
access-list 111 permit ip host 10.1.5.3 host 10.2.2.2
access-list 112 deny   tcp any any
access-list 112 deny   udp any any
access-list 112 permit ip host 10.1.5.3 host 10.2.2.2
!
line con 0
 transport input none
line aux 0
line vty 0 4
 login
!
end
```

Symbols

A

B

C

D

E

F

G

H

I

K

L

M

N

T

U

V

W